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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 898

Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief

Washington, D. C. ▼ November 8, 1920

TURPENTINE

ITS SOURCES, PROPERTIES, USES, TRANSPORTATION, AND MARKETING

WITH RECOMMENDED SPECIFICATIONS

By

F. P. VEITCH and V. E. GROTLISCH

CONTENTS

	Page		Page
Sources	1	Effect of Storage	35
Manufacture	2	Adulteration	36
Chemical Nature and Properties	4	State Laws Governing Transactions in Turpentine	38
Uses	7	Need for Uniform Specifications and Methods of Testing	41
Transportation	7	Recommended Specifications for Turpentine	43
Calculation of Capacity and Outage of Tanks	17	Statistics	49
Basis of Sale	27		
Turpentine Tables	28		

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CONTENTS.

	Page.		Page.
Sources	1	Calculation of capacity and outage of tanks	17
Manufacture	2	Basis of sale	27
Chemical nature and properties	4	Turpentine tables	28
Uses	7	Effect of storage	35
Transportation	7	Adulteration	36
Shipping in barrels	7	Simple tests for adulteration	37
Glueing barrels	8	State laws governing transactions in turpentine	38
Inspection	10	Need for uniform specifications and methods of testing	41
Shipping in tank cars	14	Recommended specifications for turpentine	43
Cleaning cars	14	Statistics	49
Loading cars	14	Exports	51
Unloading cars	15		
Painting inside of tanks	15		

SOURCES.

Gum turpentine, known also as oil of turpentine, spirits of turpentine, or "turps," is a light, volatile oil obtained from various species of the pine tree. Approximately 75 per cent of the world's supply of gum turpentine is made in the United States. By far the greater part of this is obtained from the Southern longleaf yellow pine (*Pinus palustris*). The Cuban or slash pine (*Pinus caribæa* or *heterophylla*) is frequently found, singly or in small groups, among the longleaf pines, usually in low, marshy places. This species, which yields gum more freely, and gum of a higher turpentine content than the average longleaf pine, is always tapped when found in the pine forests. The rosemary pine, a variety of the loblolly pine (*Pinus taeda*), is sometimes tapped when it occurs among the yellow pines, as some of the trees of this species produce gum freely.

A very small quantity of turpentine is produced from the Western yellow pine (*Pinus ponderosa*).

The larger part of the remaining 25 per cent of the world's supply of gum turpentine comes from the coast regions of southwestern France, in the departments of Landes and Gironde, the maritime or cluster pine (*Pinus pinaster* or *maritima*) being used for this purpose. Comparatively small quantities are produced also in Spain and Portugal from a variety of the maritime pine, known as the Spanish pine; in Greece and Algeria from the Aleppo pine (*Pinus halepensis*); in the southeastern part of France (Provence) from a cross between this variety and the more common maritime pine; in northern Italy from the stone pine (*Pinus pinea*); in Austria from the black pine (*Pinus laricio austriaca* or *nigra*), also known as the black fir; in northern India from the chir pine (*Pinus longifolia*) and the Himalayan or Bhotan pine (*Pinus excelsa*); in Mexico and Central America from the Mexican white pine (*Pinus ayacahuite*); in central Germany, Poland, and northern Russia from the Norway pine or Scotch fir (*Pinus silvestris*); and in Japan from the Japanese black fir (*Pinus thunbergii*).

Of the gum turpentine produced in the United States, Florida furnishes about 37 per cent, Georgia about 19 per cent, Louisiana about 15 per cent, Alabama about 12 per cent, Mississippi about 9 per cent, and Texas about 7 per cent. North and South Carolina together produce less than 1 per cent. Seventy years ago, before the pine forests in the other States were opened up for turpentine operations, North Carolina produced the bulk of the world's supply of turpentine.

Wood turpentine, made by distilling with steam or destructively distilling resinous stumps and dead and down timber, is gradually becoming more important in this country. At present somewhat less than 10 per cent of the total production of turpentine is wood turpentine. Wood turpentine is made by the destructive process also in Norway, Sweden, Finland, and particularly in Russia, most of it being consumed in England and Germany.

MANUFACTURE.

Gum turpentine is made by distilling, in the presence of a small quantity of water, the oleoresin or gum obtained by scarifying or "chipping" the living tree (Pl. I). On an average of once a week during the producing season, which extends from early spring to late fall, a V-shaped scar or cut is made in the trunk of the tree (Pl. II), ("putting on a streak"), just above the one previously made, thereby forming a "face." Care must be taken that the wound does not penetrate through the relatively thin layer of sapwood on the outside of the tree, just under the bark, as it is from this portion only that the gum flows. As the gum exudes from the fresh cut, it trickles

down the face and is collected in galvanized-iron or baked-clay cups which hold from 1 to 2 quarts. About once a month these cups are "dipped" (Pl. III, fig. 1) and the gum hauled to the still in barrels. A well-built still (Pl. III, fig. 2) saves labor and time, and prevents evaporation of turpentine from the gum, whereas an uncovered gum platform (Pl. IV, fig. 1) causes the dip barrels to leak and permits the evaporation of turpentine from the gum.

The equipment used for distilling the turpentine from the gum or resin is simple, and has not been materially improved in the past 50 or 60 years. It consists primarily of a large copper kettle, of from 500 to 1,000 gallons capacity, connected by a still head (usually removable) to a large copper coil set in a large tub of water for condensing the distillate. From 7 to 14 barrels of the crude gum are placed in the still, depending on the size of the still and also on the nature of the gum. Gum from third-year tappings froths more than virgin or first-year gum, for which reason less of the older gum is put in the still at a time.

The gum as it is placed in the still contains a small percentage of water, the presence of which lowers the temperature at which the turpentine will distill. At the beginning of the operation the distillate consists of about 45 per cent of turpentine and 55 per cent of water. When nearly all the water originally present has been distilled over, as shown by the decrease in the amount of water in the distillate to about 30 per cent and by the peculiar sound (termed the "call for water") heard on placing the ear close to the tail pipe of the condenser coil, a small stream of water is allowed to flow into the boiling gum in the still through an opening in the still head. Usually the mixture of turpentine and water is received in an open-headed barrel. The turpentine, being lighter than the water, rises to the top and is run off through a pipe into another open receiving barrel, from which it is either pumped to a storage tank or bailed into barrels, ready for shipment to the market. The water is allowed to flow out through an opening at the bottom. When nearly all the turpentine has been distilled out, the flow of water is shut off, the still cap or head removed, and the molten rosin remaining in the still drawn from the still through an opening at the bottom. The yield of turpentine varies from 16 to 22 per cent of the original weight of the gum.

The use of open separators and receiving barrels (Pl. V, fig. 1) is wasteful, as the turpentine, continually exposed to the air, evaporates. This loss amounts to from one-fourth to three-fourths of a gallon for each charge, depending on the temperature at which the turpentine comes from the condenser and on atmospheric conditions, such as temperature, humidity, winds, etc. To overcome this unnecessary loss, turpentine producers should equip their stills with covered automatic separators and receiving barrels (Pl. V,

fig. 2). Figure 1 shows the construction of a homemade automatic separator. A 6-inch funnel (A) is set in place in a hole in the cover of the separator barrel, which is provided with a turpentine offtake pipe (B) and a water overflow pipe (C) placed on a level with B. B fits snugly into the cover of the turpentine settling or receiving barrel (D). This cover is in two halves, and is easily removable, to permit the dipping out of the contents. For drawing off the water, a faucet (E) is placed as close to the bottom of the tank D as possible, while another (G) in the separator barrel may be assembled from 1-inch nipples and valve. To prevent the water globules from flowing through

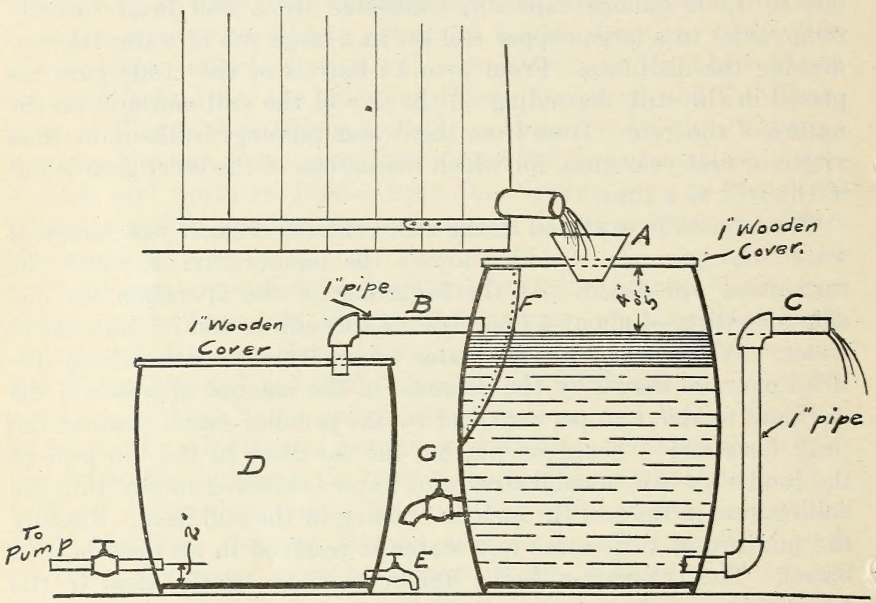

FIG. 1.—Design for homemade automatic turpentine separator barrel.

the offtake pipe (B) into the tank (D), a piece of thin cotton cloth (F) is stretched tight and tacked in place in front of the opening.

CHEMICAL NATURE AND PROPERTIES.

Freshly distilled gum spirits of turpentine consists of several similar and closely related compounds known as terpenes, together with small and varying quantities of oxidized derivatives thereof. The empirical formula of the terpenes is $C_{10}H_{16}$, indicating that turpentine consists almost entirely of carbon and hydrogen.

Of the terpenes, the one known as pinene occurs in the highest proportion in spirits of turpentine. This compound exists in several varieties which exhibit certain differences in their physical and chemical properties.

Alpha pinene is found to the extent of from 80 to 85 per cent in the average pure, fresh American gum spirits of turpentine, and to a

slightly greater extent in turpentine from virgin gum. Examination with a polariscope shows that American turpentine from the Southern yellow pine generally rotates a plane of polarized light to the right. Therefore, the pinene in American turpentine is called dextro-alpha pinene. On the other hand, French turpentine rotates the plane of polarized light to the left, because of the presence of the variety of pinene known as laevo-alpha pinene.

Among the other terpenes which have been identified in turpentine oil may be mentioned beta-pinene or nopinene, camphene, sylvestrene, and dipentene. These occur only in small quantities. The two mentioned last are also found in destructively distilled wood turpentine.

The pinene in turpentine obtained from the Cuban or slash pine (*Pinus caribæa* or *heterophylla*) is laevorotatory, like the French turpentine. The preponderance of the longleaf yellow pine (*Pinus palustris*) in the southern pineries accounts for the fact that American turpentine is generally dextrorotatory.

Since turpentine consists chiefly of pinene, its physical and chemical properties might be expected to be similar to those of pinene. The differences between them are due to the presence of small and varying quantities of other terpenes and of certain oxidation products. Pure alpha pinene boils at 155° to 156° C., has a specific gravity of from 0.858 to 0.860 at 20° C., and a refractive index of 1.4655 at 21° C. Pure beta pinene boils at 162° to 163° C., has a specific gravity of about 0.867 at 20° C. and a refractive index of 1.476 at 20° C. Accordingly, turpentine begins to distill around 155° C., has a specific gravity, at 20° C., of from 0.858 to 0.872, and a refractive index of from 1.468 to 1.478 at 20° C.

Chemically speaking, turpentine is a highly unsaturated body. It combines directly with oxygen, chlorin, bromin, iodin, hydrogen chlorid, nitric acid, sulphuric acid, and many other chemically active substances. On standing for some time in a partially filled container, especially when exposed to the light, or on exposure to the air for a shorter period in the form of a thin film, turpentine absorbs oxygen from the air (becomes oxidized). At the same time small quantities of hydrogen peroxid are liberated. It will be noticed that the cork stopper from a bottle partially filled with turpentine is bleached, like the cork in a bottle of hydrogen peroxid. As a result of the absorption of oxygen, the turpentine becomes more viscous and oily and turns yellow, a solid white deposit often forming at the bottom of the bottle. The odor becomes sharp and disagreeable, the specific gravity, the refractive index, and the boiling point are raised, and the percentage distilling up to certain limits [1] becomes less. Small quantities of acetic and other acids are formed in the turpentine.

[1] Ninety per cent up to 170° C. is the specified requirement.

These attack the tin or iron of a can or tank in which the turpentine may be stored, and the dissolved iron helps to darken the color. For this reason turpentine should not be stored in partially filled iron or tin cans or tanks unless they have first been painted inside with a turpentine-resisting paint.

The absorption of oxygen begins as soon as the gum exudes from the tree. Thus when the face is quite long, with a correspondingly longer exposure of the gum to light and air, the yield of turpentine is lowered, the odor grows less fragrant, and the gum becomes more viscous. The heavy, oily, almost resinous nature of the oxidation products, which have high boiling points, accounts in part for the increased tendency to froth during distillation of old high-box gum, and causes the turpentine obtained during the latter part of the distillation of such gum to be usually heavy and discolored, and the rosin to be decidedly darkened, due to the higher temperature which must be maintained in order to abstract all the turpentine.

Spirits of turpentine is believed to owe its superiority as a paint thinner to its property of absorbing oxygen from the air, the drying of paint being due to the absorption of oxygen from the air by the linseed or other drying oil, forming a hard insoluble film of linoxyn. It is said that turpentine acts as an oxygen carrier, transferring oxygen from the air to the linseed oil, and finally adding to the paint film the nonvolatile residue left after evaporation, which also acts like a drying oil.

Treating turpentine with small quantities of ordinary concentrated sulphuric acid forms a new hydrocarbon called terpinene with a boiling point of 180° C. Heating turpentine with larger quantities of concentrated sulphuric acid or with fuming sulphuric acid chars or carbonizes it, with the formation of small amounts of resinous matter. This action is the basis of several methods for detecting the presence of adulterants in turpentine. Strong nitric acid combines with turpentine with great energy, the latter being ignited unless kept cold. The product of such action is a brown, resinous, gummy mass. On the other hand, dilute nitric or sulphuric acid brings about a gradual conversion of the pinene in turpentine to terpene hydrate and dipentene.

On passing dry hydrogen chlorid (hydrochloric acid gas) into turpentine which is kept cold by immersing the container in a mixture of salt and ice, a combination of the two takes place, forming what is known as pinene hydrochlorid. This is a crystalline white body having an odor much like that of camphor, and is called artificial camphor. It is quite volatile at ordinary temperatures, evaporating completely when exposed to the air.

In the manufacture of synthetic camphor, which is being carried on at present on a commercial scale, the preparation of pinene

hydrochlorid from turpentine is the first step in the operation. Four more chemical steps or changes are necessary before camphor is obtained. The products obtained in these intermediate steps are known as camphene, isobornyl acetate, isoborneol, and finally camphor.

USES OF TURPENTINE.

The principal use of turpentine is for thinning paints and varnishes, approximately 85 per cent of this country's consumption being employed for this purpose. About 45 per cent is used by the manufacturers of these products, and the other 40 per cent by painters in mixing and thinning paints and varnishes at the time of application. Some 5 per cent of the domestic consumption is used for medicinal purposes, both alone and in prepared drugs and pharmaceuticals. About 3 per cent is used in the manufacture of various kinds of polishes, such as shoe polish, floor and furniture polish, leather dressings, etc., where it acts as a solvent for the waxes from which such preparations are made. It is also used in the manufacture of patent leather, and constitutes the raw material from which terpineol, terpin hydrate, and synthetic camphor are made. Terpineol is an oily liquid with a lilaclike odor, used chiefly as a perfume. Terpin hydrate is a crystalline body used in medicinal preparations for coughs and other throat affections.

Turpentine is used in the rubber industry as a solvent and as raw material for the production of isoprene, from which artificial or synthetic rubber is made; in the manufacture of calico and other print goods to prevent bleeding or running of the colors; also in the manufacture of printing ink, fireworks, wood stains, marking crayons, and many other things. The total quantity used for all these purposes, however, is almost negligible when compared with the amount consumed in the manufacture and application of paint and varnish.

TRANSPORTATION OF TURPENTINE.

SHIPPING IN BARRELS.

Practically all of the turpentine produced in South Carolina, Georgia, and eastern and southern Florida, as well as the larger part of that which comes from western Florida and Alabama, is shipped from the stills to the primary markets at the southern Atlantic and eastern Gulf ports, namely, Savannah, Brunswick, Jacksonville, Pensacola, and Mobile, in wooden barrels holding from 50 to 52 gallons. The greater portion of the turpentine shipped from the Atlantic ports to the consuming centers in the North and East, both coastwise and by rail, and practically all of the exported turpentine, is also shipped in barrels. Steel drums replace barrels to only a slight extent either for domestic or foreign shipments.

The larger producers, some of whom are located in Alabama and western Florida, but chiefly in the more western turpentine-producing

States, usually store their turpentine in large iron tanks, and ship in tank cars holding from 5,000 to 10,000 gallons, as they receive orders for the material. These shipments are made either to the ultimate consumer or to large dealers having storage facilities at northern consuming centers.

Barrels or drums obviously are better adapted to the use of the small producer or dealer than tank cars, and offer the shipper the further advantage of the lower freight rates charged for transportation by water. They have, however, the disadvantage of increasing the chances for loss by leakage and breakage, and the consequent charges for transferring the contents to tight, sound barrels. Shipping in tank cars is more economical in the long run, as it saves the cost of the barrel, insures a product more uniform in color, composition, and specific gravity, and lessens the danger of loss from leakage.

The smaller producer, who ships his turpentine to the primary market, consigns it to a merchant, known in the trade as a "factor," who acts as a commission merchant, and sells the turpentine for the producer to the dealer or exporter. The factors, with but one or two exceptions, do not buy or sell any turpentine on their own account, except in so far as they may be financially interested in places whose accounts they handle. A few factors act also as dealers and exporters, purchasing direct from the producer and selling direct to the consumer.

Glueing Barrels.

Turpentine will readily penetrate through the staves of an ordinary wooden barrel. It is therefore necessary to coat the inner surface of the barrel with ordinary glue, which is insoluble in turpentine but readily soluble in water. Turpentine soon leaks out from a barrel that has been carelessly or improperly glued, as well as from one containing any water, regardless of how well the glue was prepared or applied. Consequently, great care must be taken in preparing the glue and applying it to the barrel, and finally also in so filling the barrel with turpentine that no water gets into it.

DIRECTIONS FOR GLUEING.

As a rule, glue makers furnish with their product a formula showing the proper proportions of glue and water. The following formula is recommended by one of the largest producers of animal glue:

Glue (pounds)	20
Water (gallons)	8
Commercial borax (pound)	½
Commercial glycerin (pound) [1]	¾

Late in the afternoon place the quantity of glue required for the next day's work in a perfectly clean jacketed, or double boiler glue kettle, cover with the proper quantity of clean cold water, and allow

[1] The glycerin is added to make the glue more elastic, and may be omitted if the directions for preparing the glue here given are carefully followed.

it to dissolve slowly to a jelly. When glue prepared in this way is put on to heat the next morning it dissolves in the water rapidly and smoothly, and has the further advantage of being somewhat stronger than that which is simply mixed with cold or hot water and immediately heated.

Since animal glue rapidly loses its adhesive strength when it is subjected to a high temperature, it never should be boiled. Glue prepared in a single unjacketed kettle over an open fire will almost certainly become too hot and boil when not watched, or it will not be hot enough to properly glue the barrels without waste. In preparing the glue, then, use a double boiler or jacketed glue kettle. The boiling water in the lower pot heats the glue in the upper pot to the proper temperature without bringing it to a boil. Do not keep the glue hot longer than necessary. Have the barrels ready to glue as soon as the glue is hot, glue at once, and clean the glue kettle for the next day.

Before glueing the barrel, drive the hoops down moderately tight. Then pour about 1 gallon of the hot glue into the barrel, plug up the bunghole, and sluice the barrel around well, making sure that the glue comes into contact with every bit of the inside surface. Remove the stopper, place the barrel on a rack over the glue kettle, and allow the excess glue to drain directly into the kettle. As soon as most of the excess glue has drained out, take the barrel from the rack, and stand it on one head in a level place. About one-half hour later, drive the hoops down absolutely tight, so that the tension on the hoops all around the barrel will be equal, and let it stand on the same head, thus permitting some of the soft glue still inside the barrel to settle down in the chine where most of the leaks occur. Allow the barrel to stand, bung open, for several days under a shed, protected from the sun and rain, and then glue again exactly as before, but making sure that the barrel stands on the other head this time. After two days the barrel is ready for use. Barrels glued in this way should give little, if any, trouble from leaking, provided no water is allowed to get in.

As animal glue is extremely subject to decomposition through the action of bacteria and molds from the air, glue left in an open kettle soon begins to decompose, as shown by its foul odor, thus becoming no longer fit for use. It is, therefore, highly important to keep any left-over glue sweet and clean if it is to be used again. The unused glue should be poured into a can which may be tightly covered and stored in a cool place, and the pot thoroughly cleaned. Fresh glue is ruined if put in a filthy pot, containing decomposed, foul-smelling material. The purpose of the borax recommended in the formula on page 8 is to help keep the glue sweet, and it should be dissolved in the glue when ready for use.

Inspection.

On arrival at the primary market each barrel of turpentine is opened and inspected to determine the grade (color), purity, absence of water, and volume of contents.

Grades and grading.

The grade of turpentine is determined chiefly by the color, which varies from almost colorless to a decided yellow, depending on the age of the gum from which the turpentine was made, the season of the year when the gum was collected, the care shown in its distillation, its age, and the amount of exposure to light or air undergone after distillation.

Four merchantable grades of turpentine, known as "water white," "standard," "one shade off," and "two shades off," are recognized on the primary naval stores markets. "Standard" is the basis for price quotations. Turpentine which grades one shade off or two shades off is accepted by buyers only at a discount, and when purchased by the large dealers is usually mixed with enough water white turpentine to bring the color up to standard. Turpentine which has a color deeper than two shades off, as defined hereafter, is not merchantable under the naval stores market rules.

Since the color of some turpentine changes markedly in short periods of time, it has so far been impossible to devise color standards for turpentine which consist wholly or in part of turpentine itself. The light color of the higher grades has made it impracticable to select any colored solution, either organic or mineral, which is permanent and fast to light, as a color standard for turpentine. For the present, therefore, the grade of turpentine is determined by comparison with a No. 1 yellow Lovibond tintometer glass. The several standards, defined in terms of the depth of column which will match in color the No. 1 yellow Lovibond glass, are as follows:

Water white.—The color of a column 150 mm. in depth shall match a No. 1 yellow Lovibond tintometer glass.

Standard.—The color of a column 50 mm. in depth shall match a No. 1 yellow Lovibond tintometer glass.

One shade off.—The color of a column 25 mm. in depth shall match a No. 1 yellow Lovibond tintometer glass.

Two shades off.—The color of a column 15 mm. in depth shall match a No. 1 yellow Lovibond tintometer glass.

The color or grade is determined in the laboratory as described on page 44. This procedure, however, is not practicable for routine examination of turpentine on the storage and receiving yards. For this purpose 4-ounce, flat and polished-bottom, oil-sample bottles are completely filled with turpentines which have been recently tested and adjusted by the laboratory method, so that the required depth of column to equal the No. 1 yellow Lovibond glass is exactly 150, 50, 25, and 15 mm., respectively, and securely corked. In grading, a

similar bottle is filled with the turpentine to be graded, and the color of the column of turpentine, looking through the length of the bottle, is compared with that of the bottles containing the standard samples. It is then given the grade which it equals in color, or, in case it falls in between two, it receives the grade of the lower or darker one. As previously stated, the color of turpentine is not permanent, and it is therefore necessary to check frequently the standardized samples against the No. 1 yellow glass by the laboratory method, adjusting them when any changes in color occur.

PURITY AND PRESENCE OF WATER.

An experienced naval stores inspector usually can tell whether a turpentine is pure or adulterated by his sense of smell, which becomes very acute through continued use in the lookout for suspicious-smelling material. Moreover, the presence of a foreign odor, such as that of kerosene, in an atmosphere in which the odor of pure turpentine is always pronounced, helps to identify any barrel containing mineral oil. The usual adulterants are light mineral oils. By placing a few drops of turpentine on the hands, rubbing them together, and bringing them up to the nose, the presence of mineral oil may be detected readily, if there is very much of it. When a little of the material is allowed to evaporate from the surface of the barrel, the presence of any adulterant having a lower rate of evaporation than turpentine can be determined by the oily or greasy appearance and the odor of the unevaporated portion. If the inspector has reason to suspect a shipment, he calls in the State supervising inspector, who makes a more detailed examination, including chemical tests when necessary.

To determine the absence of water, a portion of turpentine is drawn, by means of a glass tube called a "thief," from the bottom side as the barrel lies. Since water is heavier than turpentine, it may be removed from the barrel by means of the thief, if this simple test shows that it is present.

VOLUME OF CONTENTS.

First the capacity of the barrel of turpentine is determined by measuring with a gage rod the distance from a point on either chine inside to the middle of the opposite side of the barrel, i. e., the middle of the inner side of the bunghole. A gage hook is used to indicate on the gage rod the center of the inner side of the hole. The gage rod is marked to show directly the capacity of the barrel in gallons, the average of the readings from both ends being taken as the capacity of the barrel. A symbol designating the capacity of the barrel is inscribed or cut on a stave near the bunghole.

Turpentine barrels hold from 50 to 53 gallons. All barrels offered for sale are packed to contain 1 gallon less than the full capacity, and this is called the "net gage" of the barrel. The surface of the turpentine in a barrel so filled is $1\frac{1}{2}$ inches down from the inner side of

the bunghole. This "outage," as it is termed, allows for expansion of the turpentine if the temperature should rise.

After the capacity of the barrel has been determined, the inspector measures the outage with an outage stick, which is also marked to read directly in gallons. If the outage stick shows an outage of 1 gallon, i. e., 1½ inches from the surface of the turpentine to the inside of the bunghole, the barrel is passed as in condition for sale, provided the color of the turpentine is "standard" or better, no water is present, and no indication of adulteration or leakage is shown, and the shipper is credited with the quantity of turpentine equivalent to the net gage, i. e., the gross gage or capacity less 1 gallon.

Whenever the outage rod shows more or less than 1 gallon out, the quantity lacking or over is marked in chalk on the barrel. When the entire lot of barrels have been thus gaged, those showing an outage of more than 1 gallon are packed, so that they will be just 1 gallon out, and the quantity of turpentine required is charged to the shipper at the prevailing price. He receives payment for the gross or full gage of his barrels less 1 gallon out for each barrel, which is the net gage for each barrel, and is charged for the quantity required to pack to the net gage any barrel showing an outage of more than 1 gallon. If any of his barrels contain more than the net gage, he is credited with that quantity of "overs."

Example.—A producer ships 10 barrels of turpentine which on inspection show a total gross gage or capacity of 520 gallons. Five of these barrels show an outage of 1 gallon each, i. e., they are properly filled; four show an outage of 1½ gallons each; and one an outage of only one-half gallon. In order to fill the four barrels showing an outage of 1½ gallons to the proper mark, i. e., so that there will be only 1 gallon out in each barrel, 2 gallons are needed, and this quantity is charged against the producer for "packing." A half gallon is taken from the barrel showing an outage of only one-half gallon, and credited to the shipper as "overs." The statement covering this shipment would then be as follows:

	Gallons.
Ten barrels, gross gage	520
Outs (1 gallon on each barrel)	10
Net gage	510
Packing (4 barrels, ½ gallon each)	2
Total	508
Overs (½ gallon on 1 barrel)	½
The shipper is paid for	508½

This will explain to the producer why an outage always appears on the inspection report. Every properly filled barrel shows an outage of 1 gallon. When the outage is greater than this the inspection report for that particular barrel includes the outage of 1 gallon

plus the excess outage which is charged against the operator as for "packing." If no packing charge is shown on the account sales, it signifies that the barrels were properly filled to within 1 gallon of their capacity at the time of gaging.

LEAKAGE.

Whenever a barrel containing turpentine shows signs of leaking, or has any defects, such as a broken stave, it is necessary for the inspector to "turn" the turpentine into a sound, tight barrel. Neither the dealer nor the transportation company will accept turpentine in a defective or leaky barrel. If the barrel is sound, and is leaking only, the seller pays merely to have the barrel turned, which is really the cost of reglueing the barrel. If, however, there is a broken stave, the charges cover the time and service of a cooper to replace the broken stave, in addition to the reglueing of the repaired barrel.

ALLOWANCE FOR TEMPERATURE.

As a rule, in gaging the volume of the contents of a barrel of turpentine, no correction is made for the effect of temperature on the volume. Although this difference may be ignored on a single barrel, it can not be disregarded in large transactions. The corrections for different temperatures on a 50-gallon barrel, therefore, have been compiled (Table 1) to enable turpentine gagers to correct approximately for the expansion or contraction of the turpentine in a barrel of 50 gallons, gaged at any temperature above or below the standard temperature of 60° F. It is based on the average coefficient of expansion for pure turpentine of 0.000525 per degree Fahrenheit. Since it is customary to gage to the nearest quarter gallon, this is the smallest unit considered in the table. The correction on a volume of 49 gallons is essentially the same as on one of 51 gallons. For simplicity, therefore, the corrections given have been calculated on a volume of 50 gallons, which is the average content of a barrel of turpentine. The correction for any particular temperature is given as the quarter gallon nearest the true calculated correction on a volume of 50 gallons at that temperature. Thus, Table 1 will answer all practical purposes in gaging turpentine in barrels.

TABLE 1.—*Corrections to gaged contents of a cask of turpentine to obtain true gage at standard temperature, 60° F.*

Observed temperature of turpentine.		Correction to volume as gaged add—	Observed temperature of turpentine.		Correction to volume as gaged subtract—
°C.	°F.	Gallons.	°C.	°F.	Gallons.
−12.0 to − 8.5	10 to 17	1¼	+18.5 to +23.5	65 to 74	¼
− 8.0 to − 3.5	18 to 26	1	+24.0 to +28.5	75 to 83	½
− 3.0 to + 2.0	27 to 36	¾	+29.0 to +34.0	84 to 93	¾
+ 2.5 to + 7.0	37 to 45	½	+34.5 to +39.0	94 to 102	1
+ 7.5 to +13.0	46 to 55	¼	+39.5 to +44.5	103 to 112	1¼
+13.5 to +18.0	56 to 84	None.			

SHIPPING IN TANK CARS.

Cleaning Cars.

Before loading turpentine into a tank car, the shipper should make sure, by a thorough personal inspection, that all the valves are in good working order and will close tight, and that the tank is clean inside. The statement that the tank was cleaned before leaving the place where last used, or the last point of transfer to the railroad, is not sufficient, as the railroad company, to meet some emergency, may have used it for some other purpose in the meantime, or an irresponsible person may have dumped refuse into it en route. Turpentine rendered off color or contaminated from having been shipped in a dirty or rusty container probably will be rejected by the consignee, or accepted only at a decided discount at the expense of the shipper. Therefore, turpentine should never be loaded into a dirty or rusty tank, unless specific instructions are given or permission to do so in writing is obtained from the purchaser or consignee. Whenever necessary, the tank should be cleaned and the claim for this service or expense included in the final settlement for the turpentine.

When a boiler is available, the best way to clean a dirty tank car is to blow steam [1] into it through the dome opening, leaving the bottom outlet open. The condensed steam escaping through this outlet carries with it much of the dirt and rust, at the same time driving out any fumes which may be present in the tank. After the tank has been thoroughly steamed the manhole cover may be removed and the interior flushed out with a stream of cold water. When the tank has become cool enough to permit a workman to enter, any rust or dirt adhering to the sides should be swept down with a broom and a bucket or two of water. Finally all dirt and water should be swept out of the tank through the outlet, and the outlet pipe and valve thoroughly cleaned.

As few turpentine plants have a boiler and arrangements to use steam, the tank usually must be cleaned as thoroughly as possible with a broom and water. Soap powder or a little lye dissolved in the water helps to loosen the dirt, if of a greasy nature. Finally, the tank should be thoroughly flushed or rinsed with clean water and allowed to drain. Certain precautions (p. 16) must be taken when a workman enters a turpentine tank.

Loading Cars.

The track where the tank car is cleaned should be absolutely level; otherwise, it is difficult to clean and fill it properly. Before beginning to fill the car, draw all water from the storage tank through the bot-

[1] Steam should not be used for cleaning a tank which has been painted on the inside with shellac, as it causes the shellac to crack off, necessitating repainting. Shellacked tanks should be cleaned only with water and a broom, using soap if necessary.

tom delivery pipe, taking special care that the bottom valve of the car is closed tight and does not leak. While the car is being loaded the producer or seller should take a sample, as directed on page 44. This should not be neglected, as such samples are the seller's protection against claims for adulteration, low grade, and noncompliance with specifications. The sample should be set away in a dark, cool place in a full container until payment for the turpentine is received. If the turpentine has been sold on any definite specifications, a sealed portion of the sample in a *full container* should be forwarded for test, in accordance with the terms of the contract and specifications.

Load the car until the shell is completely filled, which can be done with certainty only when the car is perfectly level from end to end. Record the temperature of the turpentine at the bottom, middle, and near the top of the tank. It must be remembered that a tank car filled in the South may show an outage of several inches or more when inspected in the North, due to the difference in temperature between the shipping and receiving points. If the average temperature of the turpentine is above or below 60° F., the contraction or expansion which will take place on cooling or warming to that temperature can be determined.

It is advisable to load tank cars from storage tanks early in the morning during hot weather. The turpentine is cool then, and the car will show less outage on arriving at its destination than it would if it had been loaded with warm turpentine. To allow for the contraction in volume which usually occurs when turpentine is shipped from southern to northern points in tank cars, many shippers load the car several inches up into the dome, according to the temperature. The higher the temperature of the turpentine when loaded, the higher in the dome the car should be filled. The total contraction for any difference in temperature may be determined as given in the specifications under "Basis of Purchase" (p. 48).

Unloading Cars.

When ready to unload, the tank car should be exactly level, especially from end to end, the outage carefully measured, and the temperature taken, as just directed. The bottom valve should then be opened slightly and any water contained in the car drained off and measured. After the water has been removed, connection should be made with a receiving tank and the valve opened wide. If the turpentine is to be tested for grade and purity, samples should be drawn while unloading, in general accordance with the instructions given on page 44.

Painting the Inside of Turpentine Tanks and Tank Cars.

When in contact with iron for any length of time, especially if the tank is only partly full, turpentine gradually turns yellow. This is

due to the fact that on exposure to air, turpentine slowly absorbs oxygen and becomes slightly acid, causing corrosion of the iron, which goes into solution, bringing about the formation of the yellow or brown color.

Unless the iron is protected against the action of the acids formed when the tank has been emptied and is full of air with a thin film of turpentine on the inner surface, tank cars in regular use for transporting turpentine soon become rusty inside. As ordinary paint, made from linseed oil and turpentine, will not resist the solvent action of turpentine, it is necessary to use a paint made from materials which are not affected by turpentine. One made according to the following formula, which makes about 8 gallons, enough to give an 8,000-gallon tank two coats, is generally used for this purpose.

Wood or denatured alcohol (gallons)	5
Orange shellac (pure) (pounds)	24
Dry red lead (pounds)	24
Venice turpentine (ounces)	28

Dissolve the shellac in the alcohol. This operation, which takes some little time, is best done by putting the two in a can and allowing the mixture to stand, covered, for two or three days, stirring occasionally. After all the shellac has gone into solution, strain the liquid through cheesecloth to remove any insoluble matter. Then warm the Venice turpentine until it flows freely and stir it into the shellac solution. This is now ready for use in making up the paint. When ready to use the paint, immediately before it is to be applied to the tank, from which all loose rust has been scraped or removed with a wire brush, mix the red lead with the liquid, being sure to stir thoroughly to break up all lumps. Apply with an ordinary paint brush to the thoroughly clean and dry surface. Brush the paint out well to prevent peeling. Allow the first coat to dry hard before applying the second coat.

Caution.—When painting the inside of a tank with this preparation, or whenever it is necessary for a man to enter a tank which has held turpentine, some arrangement must be made to prevent inhalation of the alcohol or turpentine fumes. A supply of fresh air can be pumped in to the workman through a pipe connected with either an air pump or a small blower like those connected with small portable forges. A gas mask with a container filled with broken pumice stone saturated with concentrated sulphuric acid, through which the air is drawn, may also be used. The absorption chamber must be recharged at least once a day. The pumice, in pieces about the size of a pea, should be steeped in the acid and the excess acid allowed to drain off before being placed in the container. Since concentrated sulphuric acid rapidly absorbs moisture from the air, thus losing its absorptive qualities, the acid supply and the pumice after saturation

CHIPPING YEARLING TREES, SHOWING UNRAISED CUPS, AND THE PADDLE AGAINST THE FACE WHICH PREVENTS THE FALLING OF THE CHIPS INTO THE CUPS.

COLLECTING SCRAPE, OR HARDENED RESIN, AT THE END OF THE SEASON.

with the acid must not be exposed to the air any longer than absolutely necessary. A man should not remain in such a tank for more than four hours a day, and for an even shorter period if he begins to feel unsteady, or if his muscles become "jerky." Continued work, day after day, in a tank with a wood alcohol paint should be avoided, as the poisonous effects of wood alcohol are cumulative.

Volume of Contents.

When turpentine is shipped in tank cars it is customary to fill to the dome and accept the marked capacity in gallons of the car as correct. Should the turpentine contract, as it will when the temperature falls, the car is no longer full to the dome. The contents are then determined, usually by measuring the outage, i. e., the distance from the apex of the shell of the tank to the surface of the liquid. An outage table for the particular tank in use, furnished by the company owning the car, must then be consulted, or the outage may be calculated as shown on pages 22 to 26. The noted gallonage should then be corrected to the standard temperature, 60° F. (15.5° C.), in accordance with the directions given on page 44.

CALCULATION OF CAPACITY AND OUTAGE OF TANKS.

Practically all tank cars in use on American railroads are listed in Boyd's Register, which gives their official gaged capacity. Outage tables are also usually supplied to lessees of tank cars by the owners. Many turpentine operators, however, use horizontal cylindrical tanks, such as discarded tanks from tank cars, for storage of turpentine, so that frequently it becomes desirable to be able to calculate the capacity or outage of a tank. The following outline of the procedure necessary to obtain these results is therefore included in this bulletin.

In the case of cylindrical upright tanks with flat ends, the calculation of the total capacity and the volume of contents, or in partially filled tanks, the empty space, called "outage," is comparatively simple. The capacity of the tank in cubic inches is obtained by multiplying the height of the tank, in inches, by the area of the cross section (the square of half the inside diameter of the tank, or radius in inches, multiplied by the factor 3.1416). To convert the result into gallons, it is divided by 231 (the number of cubic inches in a gallon). The formula then is as follows:

$$\text{Capacity} = \frac{3.1416 \times d^2 \times h}{4 \times 231} = 0.0034 \times d^2 \times h \text{ gallons} \quad \text{(formula 1)}$$

The quantity of liquid in such a tank, and the outage may be calculated in the same way. In the first case the depth in inches of the liquid, and in the latter case the distance from the top of the tank to the surface of the liquid, is used in place of the total depth in inches of the tank.

If the tank has a conical bottom, the volume, in cubic inches, of this part is given by the formula,

$$V_c = \frac{\pi \times d^2 \times k}{12} \qquad \text{(formula 2)}$$

in which

π = factor 3.1416.
d = inside diameter of tank, in inches.
k = height (or depth) of conical portion, in inches.

The value for V_c thus obtained must be divided by 231 to ascertain the volume of the conical bottom in gallons.

For cylindrical horizontal tanks, with dished ends, such as those on tank cars, the calculations are more involved and difficult. The dished ends of such tanks are in the form of segments of a sphere. For most practical purposes, the capacity of such a tank may be calculated approximately, as outlined for cylindrical upright tanks, by assuming the total average length of the tank to be the straight length of the sides of the cylinder plus one-half the total outside bilge at each end, or the total outside depth of either tank head. For example, if the length of the straight part of the tank is 32 feet and the outside bilge of the tank heads 6 inches, the total length of the tank may be taken as 32 feet $+ 2 \times \frac{1}{2} \times 6$ inches $=$ 32 feet 6 inches. The total outside bilge is measured by holding a straightedge against the center of the tank head, and measuring simultaneously with two rules from the butt of the end sheet on each side, adjusting the straightedge until both measurements are the same.

Often it is impracticable or even impossible to measure accurately the inside diameter of a tank. This factor, however, can be calculated from the measurement of the outside circumference of the tank, which should be determined with a steel tape. Since tanks are built up of short cylinders overlapping each other at the seams, it is evident that the inside diameter of two adjacent cylinders or sheets will not be exactly the same, but will differ by an amount equal to twice the thickness of the sheets. As every other sheet is an inside or an outside lap, there are only two different values for the diameter inside. To determine the average inside diameter of the tank, the outside circumference of one sheet of each size is measured, all measurements being converted into inches and decimal parts thereof. Each of these measurements is multiplied by the number of sheets having that circumference, the figures thus obtained being added. The sum is then divided by the total number of sheets. Multiplying this value by the factor 0.31831 gives the outside diameter of the tank in inches. Subtracting from this the sum of the thickness of the bottom sheets and of the cylindrical or shell sheets from which the tank is constructed gives the average inside diameter of the tank.

The minimum thickness of metal from which tanks of various sizes for general transportation purposes are constructed, according to specifications adopted by the Master Car Builders Association, is shown in Table 2.

TABLE 2.—*Minimum thickness of metal for constructing tanks.*

Diameter of tank.	Bottom sheet.	Shell sheet.	Tank heads.	Dome.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
60 or less	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{16}$
60 to 78	$\frac{7}{16}$	$\frac{5}{16}$	$\frac{1}{2}$	$\frac{5}{16}$
78 to 96	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{16}$

To calculate exactly the total loaded capacity of a tank car it is necessary to determine the volume of the straight or cylindrical length of the tank, and also that of the two dished ends. To the sum of these is added the volume of the so-called "dome pockets" (fig. 2), that is, the space taken up by liquid in the round dome when the tank is entirely full to the apex of the shell.

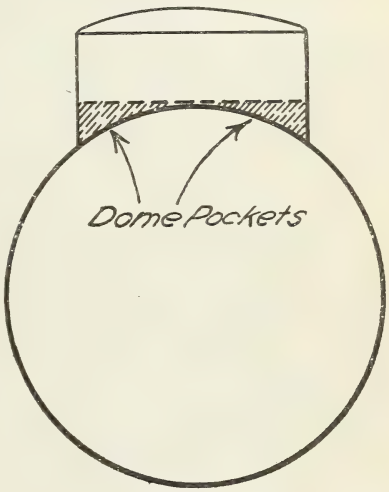

FIG. 2.

The dished ends of the tank are segments of a large sphere. Present practice in tank-car construction is to bend the dished ends on a radius of 10 feet for all sizes of tanks. When the tank end is bent, a short cylindrical portion always extends out from the spherical part, through which it is riveted to the body of the tank.

A portion of this short cylindrical part of the tank head usually extends out from the butt of the end sheet of the shell, a distance of about 1 inch, and is known as the "regular extension." The inside length of the regular extension is approximately $\frac{1}{4}$ inch less than the outside measurement from the butt of the end sheet of the cylinder to the point where the curve of the head starts. The total depth of the dish or bilge is equal to the sum of the regular extension plus the bilge proper, and, since the head fits inside the tank and the thickness of metal for tank heads of all sizes is one-half inch, the inside diameter of the tank head is 1 inch less than the inside diameter of the end sheet. The latter is determined, as before, by multiplying the outside circumference, in inches, by 0.31831 and subtracting the sum of the thickness of metal used for the shell and bottom sheets.

In order, then, to accurately determine the volume of such a tank head, the volume of the cylindrical regular extension, as well as that of the dished or spherical portion, must be calculated. The volume of the regular extension is determined in the same way as the body of the tank (p. 17), using the proper value for the inside diameter. To calculate the dished portion, it is first necessary to determine the net depth, inside, of the dished portion, which can be done by means of the formula,

$$b = R - \sqrt{R^2 - r^2} \qquad \text{(formula 3)}$$

in which

b = net inside depth of dishing or bilge, in inches.
R = 120 inches, or the radius of the sphere, of which the dished end is a segment.
r = radius of the base of this segnemt, or one-half the inside diameter of the regular extension, in inches.

Having determined the value of b, in inches, for the size tank under consideration, it should be applied to the formula for determining the volume of a spherical segment, thus,

$$V_b = 0.5236 \times b \times (3r^2 + b^2) \qquad \text{(formula 4)}$$

in which

V_b = volume of the spherical segment, i. e., the tank end, in cubic inches.
b = depth of dishing or bilge.
r = radius, or one-half the inside diameter of the tank.

Since a gallon (United States liquid measure) contains 231 cubic inches, the value for V_b thus obtained must be divided by 231 to give the volume of the dished part of the tank end, in gallons. The formula then becomes

$$\text{Volume (in gallons)} = \frac{0.5236 \times b \times (3\ r^2 + b^2)}{231}$$

The total capacity of the dome pockets depends on the diameter of the dome and the diameter of the tank on which the dome rests. Some of the usual cases are given in Table 3.

TABLE 3.—*Dome pocket capacity.*

Diameter of dome.	Diameter of tank.	Total capacity of dome pockets.	Diameter of dome.	Diameter of tank.	Total capacity of dome pockets.	Diameter of dome.	Diameter of tank.	Total capacity of dome pockets.
Inches.	*Inches.*	*Gallons.*	*Inches.*	*Inches.*	*Gallons.*	*Inches.*	*Inches.*	*Gallons.*
30	74	2.3	44	60	14.0	54	72½	26.0
32	68	3.3	44	68	12.0	54	78	24.5
32	78	2.8	44	78	10.0	54	83	21.0
36	62	5.0	44	86½	9.0	58	89½	20.0
42	80	9.0	52	78	21.0	58	78½	28.0
42	83	8.0	52	86½	19.0			

Example.—To calculate the total capacity or total contents of a full tank car with dished ends, having the following dimensions:

Length of straight or cylindrical body of tank	32 feet 4 inches (388 inches).
Regular extension, outside	$1\frac{1}{4}$ inches.
Average inside diameter	6 feet 6 inches (78 inches).
Inside diameter of tank head	$77\frac{1}{4}$ inches.
Dome diameter	3 feet 8 inches (44 inches).

First, calculate the volume of the straight part or body of the tank by means of the formula,

$$V_s = 3.1416 \times r^2 \times L = 3.1416 \times 39^2 \times 388 = 1{,}854{,}019 \text{ cubic inches}$$

(formula 5)

Next, calculate the volume of one of the tank heads, consisting of the regular extension and the bilge. The regular extension, being cylindrical, is calculated by formula 5 in which $r = \frac{1}{2}$ of $77\frac{1}{4}$ inches = 38.6 inches, and L = the inside length = $1\frac{1}{4} - \frac{1}{4} = 1$ inch. Then the regular extension volume, $V_r = 3.1416 \times 38.6^2 \times 1 = 3.1416 \times 1490 \times 1 =$ 4,681 cubic inches.

The volume of the bilge, V_b, is determined by formula 4, first finding the value for b, or the inside depth of the dished part of the tank head, by formula 3. As stated previously, $R = 10$ feet or 120 inches and $r = \frac{1}{2}$ the inside diameter of the tank head, or 38.6 inches. Substituting these values in the formula,

$$b = 120 - \sqrt{120^2 - 38.6^2} = 120 - \sqrt{14{,}400 - 1{,}490} = 6.4 \text{ inches.}$$

Substituting this value in formula 3,

$$V_b = 0.5236 \times 6.4 \times (3 \times 38.6^2 + 6.4^2) = 0.5236 \times 6.4 \times (3 \times 1{,}490 + 40.96)$$
$$= 0.5236 \times 6.4 \times 4{,}510.96 = 15{,}116 \text{ cubic inches.}$$

The total volume of the whole tank head, V_h, is the sum of V_r and V_b, or $4{,}681 + 15{,}116 = 19{,}797$ cubic inches. If the regular extension and the circumference, or inside diameter, at both ends of the tank are the same, the volume of the two ends of the tank will be twice 19,797, or 39,594 cubic inches. Then the total volume of the tank shell becomes $1{,}854{,}019 + 39{,}594 = 1{,}893{,}613$ cubic inches, which, when divided by 231 (cubic inches per gallon), gives 8,197 gallons. To this must be added the capacity of the dome pockets, which for a 44-inch dome on a 78-inch tank, is 10 gallons, making the full-load capacity of the car equivalent to 8,207 gallons.

For horizontal cylindrical storage tanks with flat ends, the total capacity is calculated as for upright cylindrical tanks,

$$V \text{ (in gallons)} = \frac{3.1416 \times r^2 \times L}{231}$$

in which

$r = \frac{1}{2}$ the average inside diameter of the tank, in inches.
L = inside length, or the distance between the two ends, in inches.

CALCULATION OF SMALL OUTAGES ON HORIZONTAL CYLINDRICAL TANKS AND TANK CARS.

The outage, or empty space, in a tank car is in the form of a segment of a horizontal cylinder, which would be formed by the segment of a circle passing along the length of the car from end to end. In addition to this there would be a small empty space in either of the dished ends of the car. This is, however, almost negligible for very small outages, that is, 2 or 3 inches. The exact calculation of the outage in the dished end of a tank is very difficult, and can not be made by simple mathematics. Complicated charts constructed from the results of involved mathematical calculations are used for this. For small outages up to 12 inches, it can be determined approximately, close enough for all practical purposes, by the method given on page 24.

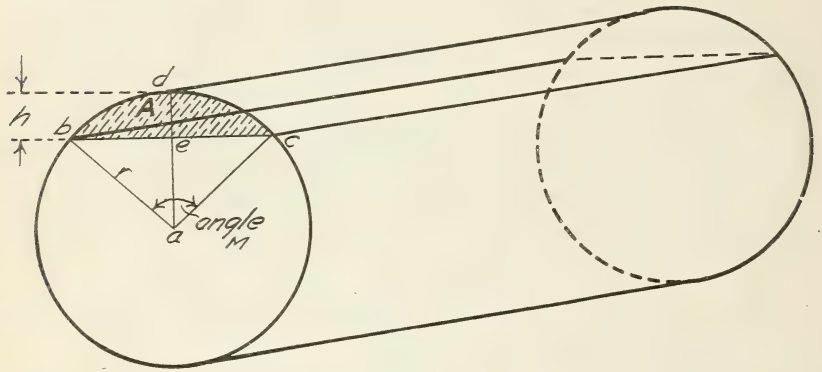

FIG. 3.

The volume of the outage in the body of the tank, in cubic inches, is equal to the area of the segment A (the dotted cross section in figure 3) multiplied by the length of the car, in inches.

For outage calculations it is simpler to consider the regular extensions of the tank heads along with the length of the body of the tank, rather than as parts of the tank heads. If the length of the body of the tank is designated by L and the inside length of a regular extension L_r, the total cylindrical length, for the calculation of the outage in the body of the tank, will be equal to the sum of the length of the body of the tank and the two regular extensions at either end, or

$$L_t = L + 2 \times L_r \qquad \text{(formula 6)}$$

Then the main outage volume becomes

$$V = A \times L_t \qquad \text{(formula 7)}$$

It is first necessary to find the value for A, by means of the formula

$$A \text{ (the area of a circular segment)} = \frac{\pi\ r^2 M}{360} - \frac{C}{2} \times (r - h) \qquad \text{(formula 8)}$$

in which

π = factor 3.1416.
r = radius of tank ($\frac{1}{2}$ average inside diameter).
M = angle subtended by the chord whose length is C, which is the base of the segment A.
h = height of the segment, or the measured outage from the top of the car.

Taking as a definite example for solution a tank car having the following dimensions: Length of body, 32 feet 4 inches; regular extensions inside, 1 inch each; average inside diameter, 78 inches; diameter of dome, 44 inches; and an outage of 6 inches,

$r = \frac{1}{2}$ inside diameter = 39 inches.
h = outage = 6 inches.
L_t = total cylindrical length of tank = 388 inches + 2 inches = 390 inches.

The first step is to calculate the angle M. If the line ad is drawn bisecting the angle M, it will be perpendicular to the chord bc, and the triangles aec and aeb will be right angled at the point e. In the triangle aec two sides are known, namely, side ac = radius = 39 inches, and side ae, the difference between the whole line ad (radius) and the height of the segment ed (h = 6 inches), making side ae = 33 inches. These two lines are, respectively, the hypotenuse and the adjacent side of the angle cae ($\frac{1}{2}$ of the whole angle M). In any right-angle triangle, the cosine of any acute angle is equal to the quotient of the side adjacent to the angle divided by the hypotenuse. In this case, the cosine of angle $cae = \frac{ae}{ac} = \frac{33}{39} = 0.8461$. A table of natural trigonometric functions shows that 0.8461 is the cosine of angle 32° 13′, or, expressed decimally, 32.22°. If angle cae is 32.22°, the whole angle cab, or M, is 64.44°.

The next step is to calculate the length of the chord C, or line bc, in figure 3. This can be done in two ways, the simpler of which is here given. In any right-angle triangle, such as triangle aec, the square of the hypotenuse (line ac) is equal to the sum of the square of the other two sides. Then

$$ac^2 = ae^2 + ec^2$$

or transposing,

$$ec^2 = ac^2 - ae^2$$

ac = 39 inches, or ac^2 = 1,521 square inches
ae = 33 inches, or ae^2 = 1,089 square inches

then $ec^2 = 1{,}521 - 1{,}089 = 432$ square inches,

and, extracting square root, ec = 20.8 inches (approximately). Since ec is only half of the entire chord, the whole chord C (line bc) = 41.6 inches, and $\frac{C}{2}$ = 20.8 inches.

Substituting the found values in formula 8,

$$A=\frac{\pi r^2 M}{360}-\frac{C}{2}\times(r-h)=\frac{3.1416\times 1521\times 64.44}{360}-(20.8\times 33)$$

which solves down to $A=168.93$ square inches.

Then, substituting in formula 7,

V_o (main outage) $=A\times L_t=168.93\times 390=65{,}882.7$ cubic inches $=285.2$ gallons.

To calculate approximately the outage in the dished end of the car, the following procedure is recommended. First, assume that instead of being dished spherically, the end is dished in the form of a flat cone, having the same volume. In figure 4 the continuous lines show the outline of the tank head as actually made, dished in the

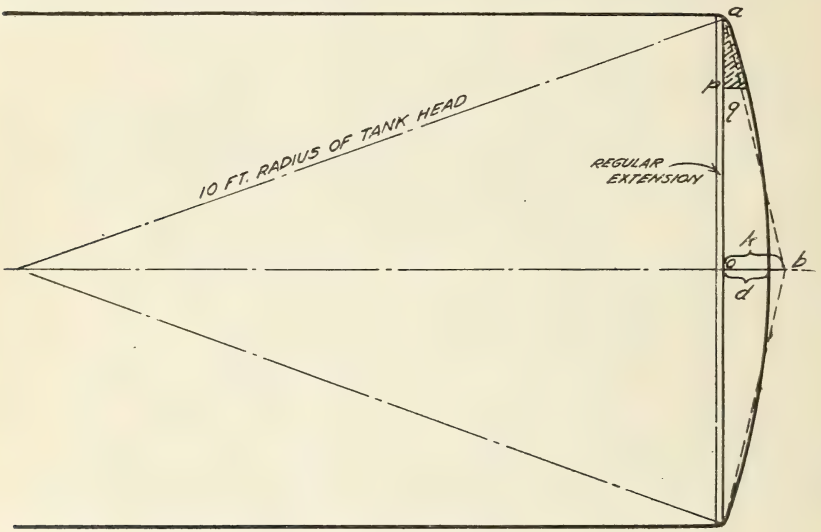

FIG. 4.

form of a spherical segment having a radius of 10 feet. The dotted line shows the outline of the conical tank head, having the same volume as the spherical head. The formula for the volume of a cone is

$$V_c=\frac{\pi\times d^2\times k}{12} \qquad \text{(formula 2)}$$

in which

$\pi=3.1416$.

$d=$ diameter of base of cone, or inside diameter of tank. Theoretically the inside diameter of the tank head should be used as the value of d, but the results are practically identical in both cases.

$k=$ height of cone. If the end were actually dished conically, k would equal the depth of dishing.

Since the values of V_c and d are known in this case, V_c being equal to V_b, the volume of the bilged end of the tank (as calculated on p. 20), k, or the depth of dishing for a cone having the same capacity as the spherical end of the tank, can be determined. Transposing, formula 2 becomes

$$k = \frac{12 \times V_c}{\pi \times d^2} = \frac{3.819 \times V_c}{d^2} \qquad \text{(formula 9)}$$

In this example, $V_c = 15{,}116$ cubic inches and $d = 78$ inches. Substituting these values in formula 9,

$$k = \frac{3.819 \times 15116}{6084} = 9.5 \text{ inches (approximately).}$$

This value for k is the length of the line ob.

Having found the value of k, the next step is to ascertain the maximum distance for any particular outage from the end of the straight part or body of the tank to the surface of the imaginary conical end, i. e., line pq in figure 4. aob and apq are similar triangles, and the ratio of ap to pq is the same as that of ao to ob. That is,

$$\frac{ap}{pq} = \frac{ao}{ob}, \text{ or } pq = \frac{ob \times ap}{ao} \qquad \text{(formula 10)}$$

The values of ap, ob and ao are known, being, respectively, 6 inches (the measured outage), 9.5 inches (the value for k), and 39 inches (the radius of the tank). Substituting these values in formula 10,

$$pq = \frac{9.5 \times 6}{39} = 1{:}47 \text{ inches.}$$

The second assumption to be made in this solution is that the outage in the end (represented by the shaded portion in figure 4) bears the same ratio to the volume of one-half the entire dished end as the area of the triangle apq bears to the triangle aob. That is,

$$\text{Outage sought: } \frac{V_b}{2} :: \text{area } apq : \text{area } aob$$

$$\text{Or, outage} = \frac{\frac{V_b}{2} \times \text{area } apq}{\text{area } aob} \qquad \text{(formula 11)}$$

V_b = volume of the bilged end of the tank head.

The area of the triangle $apq = \frac{ap \times pq}{2} = \frac{6 \times 1.47}{2} = 4.4$ square inches, and the area of the triangle $aob = \frac{ao \times ob}{2} = \frac{39 \times 9.5}{2} = 185.2$ square inches. Substituting these values in formula 11, this becomes

$$\text{Tank end outage} = \frac{7551 \times 4.4}{185.2} = 180 \text{ cubic inches (approximately).}$$

Since this is the outage at one end only, the total outage at the two ends of the tank is 360 cubic inches, which is equivalent to approximately 1.5 gallons.

The dome pockets (Table 3) for a dome 44 inches in diameter on a 78-inch diameter tank hold, when full, 10 gallons. In order to determine whether these pockets will be entirely empty at any particular outage, compare the length of the chord C (line bc), as calculated on page 23, with the diameter of the dome. If the value of this chord is equal to or greater than the diameter of the dome, the pockets will be empty. If C is less than the diameter of the dome, there will be some liquid in the pockets. In the present case C is equal to 41.6 inches and the dome diameter to 44 inches, so that there will be some liquid in the pockets.

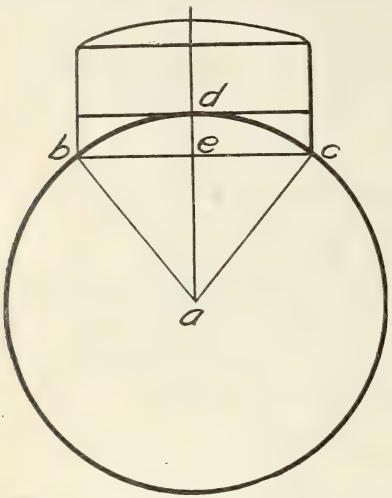

FIG. 5.

The quantity of liquid in the dome pockets at any particular outage can be determined approximately in the following manner: First determine the maximum depth of the dome pockets, i. e., the outage at which they will be just empty, represented by the line de in figure 5. In the right-angle triangle aec, $ac^2 = ae^2 + ec^2$, or $ae^2 = ac^2 - ec^2$.

Then,

$$ae = \sqrt{ac^2 - ec^2}.$$

Since ac and ec are known, being, respectively, the radii of the tank and dome, ae can be determined. The difference between the radius of the tank and ae represents the length of the line de, which is the maximum depth of the dome pockets. Table 4 shows the proportion of the total dome pocket capacity, as given in Table 3, page 20, which is empty for any particular ratio between the measured outage and the maximum depth of the dome pocket.

TABLE 4.—*Proportion of total dome capacity empty for various ratios.*

Ratio of outage measurement to depth of dome pocket.	Proportion of total dome pocket capacity that is empty.
$\frac{1}{8}$	$\frac{3}{10}$
$\frac{1}{4}$	$\frac{1}{2}$
$\frac{3}{8}$	$\frac{2}{3}$
$\frac{1}{2}$	$\frac{3}{4}$
$\frac{5}{8}$	$\frac{7}{8}$
$\frac{3}{4}$	$\frac{9}{10}$
$\frac{7}{8}$	Practically entirely empty.

In this example the depth of the dome pocket, as determined by the method just given, is 6.8 inches, and the measured outage is 6 inches. The ratio of 6 to 6.8 is slightly greater than $\frac{7}{8}$, and accordingly the dome pockets are practically empty. Therefore, the total dome pocket capacity (10 gallons) must be added to the outage volume as calculated for the tank proper. The total outage on this car, then, is the sum of 285.2 + 1.5 + 10 gallons, or 296.7 gallons.

BASIS OF SALE.

In this country turpentine is sold almost exclusively by the United States gallon, which measures 231 cubic inches; in England it is sold by the hundredweight (112 pounds); and on the continent of Europe by the kilogram (2.2046 pounds), commonly known as the "kilo."

Turpentine shipped in tank cars is sometimes weighed and the gallonage calculated from the weight. In this case the commercial practice is to consider 7 pounds as a gallon. In most cases, however, this is incorrect, as only the very lightest turpentines at temperatures above 100° F. weigh as little as 7 pounds per gallon, as shown in Table 5. The exact weight per gallon of any lot of turpentine at various temperatures can be found from Table 5.

If turpentine is purchased by volume, it should be paid for on the basis of the volume at the standard temperature of 60° F. This may be determined as shown in example 2, page 48. If purchased by weight, it should be paid for at so much per pound or per 100 pounds.

In weighing a car of turpentine the stenciled weight of the empty car is usually accepted as correct. If a reliable railroad scale (known to be correct) is available, however, it is safer to weigh the car before and after loading, thus obtaining the true weight of the turpentine, as any error in the scale reading would appear in both the loaded and empty weight of the car. The weight of a railroad car as given in bills of lading is frequently incorrect by as much as 200 pounds, due to inaccuracy of scales, carelessness in weighing, or weighing cars which are wet or coupled to other cars not on the scales.

Obviously, then, the purchase of turpentine in tank carlots, at so much per gallon, based on a preassumed weight per gallon (commonly 7 or 7.2 pounds per gallon) introduces possibilities of two important errors in judging the quantity of the contents, one due to inaccurate weighing on railroad scales, the other to the difference between the actual weight per gallon of the particular turpentine and the assumed weight. As a matter of fact, a pure turpentine which weighs as little as 7 pounds per gallon, equivalent to a specific gravity of approximately 0.841 at 15.5°/15.5° C., is never obtained from present sources of American turpentine.

TURPENTINE TABLES.

In the purchase or sale of turpentine in large lots, it is often desirable to determine the net weight of the shipment from the measured gallonage, or vice versa. The weight of a gallon of turpentine varies with its temperature and its composition, which is not always the same, as shown by the fact that at 60° F. (15.5° C.) the specific gravity[1] of pure American gum spirits varies between 0.862 and 0.875.

---

[1] The term specific gravity as applied to liquids and solids is usually defined as the ratio between the weights, or more correctly the masses (i. e., the weights in vacuum), of equal volumes of the material under discussion and of water, the temperature of each being either definitely stated or implied.

The apparent weight of a body in air is in most cases slightly less than its mass, or weight in vacuum, due to the buoyant effect of the air displaced by that body. The difference between the weight in air and the weight in vacuum is equal to the weight of a volume of air equivalent to the difference between the volume of the body being weighed and of the weights used to counterbalance it. All scales are calibrated or checked against weights whose weight has been determined by counterbalancing against standard brass weights.

The statement "specific gravity of turpentine at 60°/60° F. equals 0.864," therefore, means that the mass (weight) of any volume of the turpentine at a temperature of 60° F. is only 864/1000 of the mass (weight) of an equal volume of water at the same temperature. "Specific gravity, 20°/15.5° C.=0.870" means that the mass (weight) of any volume of the liquid at a temperature of 20° C. is 870/1000 of the mass (weight) of an equal volume of water at 15.5° C. When only one temperature is given, as in the statement "sp. gr. 15.5° C. =0.864," it is implied or understood that both the liquid and the water are at the same temperature as in the first case.

Whenever the mass of any volume of liquid is compared with the mass of an equal volume of water at a temperature of 4° C., at which temperature the weight of any volume of water is at its maximum, this ratio is called the "density" of the liquid. Since the density of water is taken as 1.000 at 4° C., i. e., the mass (weight) of 1 cubic centimeter of water at this temperature is 1.000 gram, the statement "density, 15.5° C.=0.870" means that the mass of 1 cubic centimeter of the liquid is 0.870 gram at the stated temperature, 15.5° C.

TABLE 5.—*Weight of 1 gallon of turpentine at various temperatures.*[1]

Temperature.		Specific gravity at 15.5°/15.5° C. or 60°/60° F.																				
		0.8600	0.8610	0.8620	0.8630	0.8640	0.8650	0.8660	0.8670	0.8680	0.8690	0.8700	0.8710	0.8720	0.8730	0.8740	0.8750	0.8760	0.8770	0.8780	0.8790	0.8800
		Weight of turpentine in pounds per gallon.																				
°C.	°F.																					
−6.7	20	7.3103	7.3187	7.3272	7.3357	7.3441	7.3526	7.3610	7.3694	7.3778	7.3863	7.3947	7.4032	7.4116	7.4200	7.4285	7.4369	7.4454	7.4539	7.4623	7.4708	7.4793
−5.6	22	7.3028	7.3113	7.3197	7.3282	7.3366	7.3451	7.3535	7.3619	7.3703	7.3788	7.3872	7.3957	7.4041	7.4125	7.4210	7.4294	7.4379	7.4464	7.4548	7.4633	7.4718
−4.4	24	7.2953	7.3038	7.3122	7.3207	7.3291	7.3376	7.3460	7.3544	7.3628	7.3713	7.3797	7.3882	7.3966	7.4050	7.4135	7.4219	7.4303	7.4388	7.4472	7.4557	7.4642
−3.3	26	7.2879	7.2964	7.3048	7.3132	7.3216	7.3301	7.3385	7.3469	7.3553	7.3638	7.3722	7.3807	7.3891	7.3975	7.4060	7.4144	7.4228	7.4313	7.4397	7.4482	7.4566
−2.2	28	7.2804	7.2889	7.2973	7.3058	7.3142	7.3226	7.3310	7.3394	7.3478	7.3563	7.3647	7.3732	7.3816	7.3900	7.3985	7.4069	7.4153	7.4237	7.4322	7.4406	7.4490
−1.1	30	7.2729	7.2814	7.2898	7.2983	7.3067	7.3151	7.3235	7.3319	7.3403	7.3488	7.3572	7.3657	7.3741	7.3825	7.3910	7.3994	7.4078	7.4162	7.4246	7.4331	7.4415
0	32	7.2655	7.2739	7.2824	7.2908	7.2992	7.3076	7.3160	7.3244	7.3328	7.3413	7.3497	7.3581	7.3666	7.3750	7.3834	7.3918	7.4002	7.4086	7.4170	7.4255	7.4339
+1.1	34	7.2580	7.2665	7.2749	7.2833	7.2917	7.3001	7.3085	7.3169	7.3253	7.3338	7.3422	7.3506	7.3591	7.3675	7.3759	7.3843	7.3927	7.4011	7.4095	7.4179	7.4263
2.	36	7.2505	7.2589	7.2674	7.2758	7.2842	7.2926	7.3010	7.3094	7.3178	7.3262	7.3347	7.3431	7.3515	7.3599	7.3683	7.3767	7.3851	7.3935	7.4019	7.4103	7.4187
3.3	38	7.2431	7.2515	7.2599	7.2683	7.2767	7.2851	7.2935	7.3019	7.3103	7.3187	7.3271	7.3355	7.3439	7.3523	7.3607	7.3691	7.3775	7.3859	7.3943	7.4027	7.4111
4.4	40	7.2356	7.2440	7.2524	7.2608	7.2692	7.2776	7.2860	7.2944	7.3028	7.3112	7.3196	7.3280	7.3364	7.3448	7.3532	7.3616	7.3700	7.3784	7.3868	7.3952	7.4036
5.6	42	7.2281	7.2365	7.2449	7.2533	7.2617	7.2701	7.2785	7.2869	7.2953	7.3037	7.3121	7.3205	7.3289	7.3373	7.3457	7.3541	7.3624	7.3708	7.3792	7.3876	7.3960
6.7	44	7.2207	7.2291	7.2375	7.2459	7.2543	7.2627	7.2710	7.2794	7.2878	7.2962	7.3046	7.3130	7.3214	7.3297	7.3381	7.3465	7.3549	7.3632	7.3716	7.3800	7.3884
7.8	46	7.2132	7.2216	7.2300	7.2384	7.2468	7.2552	7.2635	7.2719	7.2803	7.2887	7.2971	7.3055	7.3139	7.3222	7.3306	7.3389	7.3473	7.3557	7.3641	7.3725	7.3808
8.9	48	7.2057	7.2141	7.2225	7.2309	7.2393	7.2477	7.2560	7.2644	7.2728	7.2812	7.2896	7.2980	7.3063	7.3146	7.3230	7.3314	7.3397	7.3481	7.3565	7.3649	7.3732
10.0	50	7.1983	7.2067	7.2151	7.2235	7.2318	7.2402	7.2485	7.2569	7.2653	7.2737	7.2821	7.2905	7.2988	7.3071	7.3155	7.3238	7.3322	7.3406	7.3489	7.3573	7.3656
11.1	52	7.1908	7.1992	7.2076	7.2160	7.2243	7.2327	7.2410	7.2494	7.2577	7.2661	7.2745	7.2829	7.2912	7.2995	7.3079	7.3163	7.3246	7.3330	7.3414	7.3498	7.3581
12.2	54	7.1833	7.1917	7.2001	7.2085	7.2168	7.2252	7.2335	7.2419	7.2502	7.2586	7.2670	7.2754	7.2837	7.2920	7.3004	7.3087	7.3170	7.3254	7.3338	7.3422	7.3505
13.3	56	7.1759	7.1843	7.1926	7.2010	7.2093	7.2177	7.2260	7.2343	7.2426	7.2510	7.2594	7.2678	7.2761	7.2844	7.2928	7.3011	7.3095	7.3179	7.3263	7.3346	7.3429
14.4	58	7.1684	7.1768	7.1851	7.1935	7.2018	7.2102	7.2185	7.2268	7.2351	7.2435	7.2518	7.2602	7.2685	7.2769	7.2853	7.2936	7.3019	7.3103	7.3187	7.3270	7.3353
15.5	60	7.1609	7.1693	7.1776	7.1860	7.1943	7.2027	7.2110	7.2193	7.2276	7.2360	7.2443	7.2527	7.2610	7.2693	7.2777	7.2860	7.2943	7.3027	7.3111	7.3194	7.3277
16.7	62	7.1534	7.1618	7.1701	7.1785	7.1868	7.1952	7.2035	7.2118	7.2201	7.2284	7.2368	7.2451	7.2534	7.2618	7.2702	7.2785	7.2868	7.2951	7.3035	7.3118	7.3201
17.8	64	7.1459	7.1543	7.1626	7.1710	7.1793	7.1876	7.1959	7.2043	7.2126	7.2209	7.2292	7.2376	7.2459	7.2542	7.2626	7.2709	7.2792	7.2875	7.2959	7.3042	7.3125
18.9	66	7.1384	7.1468	7.1551	7.1635	7.1718	7.1801	7.1884	7.1967	7.2050	7.2134	7.2217	7.2300	7.2383	7.2466	7.2550	7.2633	7.2716	7.2799	7.2883	7.2966	7.3049
20.0	68	7.1309	7.1393	7.1476	7.1559	7.1642	7.1726	7.1809	7.1892	7.1975	7.2058	7.2141	7.2225	7.2308	7.2391	7.2474	7.2557	7.2640	7.2723	7.2807	7.2890	7.2973
21.1	70	7.1234	7.1318	7.1401	7.1484	7.1567	7.1650	7.1733	7.1816	7.1899	7.1983	7.2066	7.2149	7.2232	7.2315	7.2398	7.2481	7.2564	7.2647	7.2730	7.2813	7.2896
22.2	72	7.1160	7.1243	7.1326	7.1409	7.1492	7.1575	7.1658	7.1741	7.1824	7.1907	7.1990	7.2073	7.2156	7.2239	7.2322	7.2405	7.2488	7.2571	7.2654	7.2737	7.2820
23.3	74	7.1085	7.1168	7.1251	7.1334	7.1417	7.1500	7.1583	7.1666	7.1748	7.1831	7.1914	7.1997	7.2080	7.2163	7.2246	7.2329	7.2412	7.2495	7.2578	7.2661	7.2744
24.4	76	7.1010	7.1093	7.1176	7.1259	7.1341	7.1424	7.1507	7.1590	7.1673	7.1756	7.1839	7.1922	7.2004	7.2087	7.2170	7.2253	7.2336	7.2419	7.2502	7.2585	7.2668
25.6	78	7.0935	7.1018	7.1100	7.1183	7.1266	7.1349	7.1432	7.1515	7.1597	7.1680	7.1763	7.1846	7.1928	7.2011	7.2094	7.2177	7.2260	7.2343	7.2426	7.2509	7.2591
26.7	80	7.0860	7.0943	7.1025	7.1108	7.1191	7.1274	7.1356	7.1439	7.1521	7.1604	7.1687	7.1770	7.1852	7.1935	7.2018	7.2101	7.2184	7.2267	7.2350	7.2432	7.2515
27.8	82	7.0785	7.0868	7.0950	7.1033	7.1115	7.1198	7.1281	7.1364	7.1446	7.1529	7.1611	7.1694	7.1776	7.1859	7.1942	7.2025	7.2108	7.2191	7.2273	7.2356	7.2439
28.9	84	7.0710	7.0793	7.0875	7.0958	7.1040	7.1123	7.1205	7.1288	7.1370	7.1453	7.1535	7.1618	7.1700	7.1783	7.1866	7.1949	7.2032	7.2115	7.2197	7.2280	7.2362

[1] Some of the data given in Bureau of Standards Technologic Paper 9 have been used in the compilation of this table. The figures represent the weight in dry air at 760 mm. pressure, at the same temperature as the turpentine, except that for temperatures above 90° F. the temperature of the air was assumed to be not more than 90° F.

TABLE 5.—*Weight of 1 gallon of turpentine at various temperatures*—Continued.

Temperature.		Specific gravity at 15.5°/15.5° C. or 60°/60° F.																			
		0.8600	0.8610	0.8620	0.8630	0.8640	0.8650	0.8660	0.8670	0.8680	0.8690	0.8700	0.8710	0.8720	0.8730	0.8740	0.8750	0.8760	0.8770	0.8780	0.8790	0.8800
		Weight of turpentine in pounds per gallon.																			
°C.	°F.																				
30.0	86	7.0635	7.0718	7.0800	7.0883	7.0965	7.1047	7.1130	7.1213	7.1295	7.1377	7.1459	7.1542	7.1624	7.1707	7.1790	7.1873	7.1956	7.2039	7.2121	7.2204	7.2286
31.1	88	7.0559	7.0642	7.0725	7.0807	7.0889	7.0972	7.1054	7.1137	7.1219	7.1301	7.1383	7.1466	7.1548	7.1631	7.1714	7.1797	7.1880	7.1962	7.2045	7.2127	7.2209
32.2	90	7.0484	7.0567	7.0649	7.0731	7.0814	7.0896	7.0979	7.1061	7.1143	7.1225	7.1307	7.1390	7.1472	7.1555	7.1638	7.1721	7.1804	7.1886	7.1968	7.2051	7.2133
33.3	92	7.0408	7.0491	7.0573	7.0655	7.0738	7.0821	7.0903	7.0985	7.1067	7.1149	7.1231	7.1314	7.1396	7.1479	7.1562	7.1645	7.1727	7.1810	7.1892	7.1974	7.2056
34.4	94	7.0332	7.0415	7.0497	7.0580	7.0663	7.0745	7.0827	7.0909	7.0991	7.1073	7.1155	7.1238	7.1320	7.1403	7.1486	7.1569	7.1651	7.1733	7.1815	7.1897	7.1979
35.6	96	7.0257	7.0340	7.0422	7.0504	7.0587	7.0669	7.0751	7.0833	7.0915	7.0997	7.1079	7.1162	7.1244	7.1327	7.1410	7.1492	7.1575	7.1657	7.1739	7.1821	7.1903
36.7	98	7.0181	7.0264	7.0346	7.0428	7.0511	7.0593	7.0675	7.0757	7.0839	7.0921	7.1003	7.1086	7.1168	7.1251	7.1333	7.1416	7.1498	7.1580	7.1662	7.1744	7.1826
37.8	100	7.0106	7.0188	7.0270	7.0352	7.0435	7.0517	7.0599	7.0681	7.0763	7.0845	7.0927	7.1010	7.1092	7.1175	7.1257	7.1339	7.1421	7.1503	7.1585	7.1667	7.1749
38.9	102	7.0030	7.0112	7.0194	7.0276	7.0359	7.0441	7.0523	7.0605	7.0687	7.0769	7.0851	7.0934	7.1016	7.1099	7.1181	7.1263	7.1345	7.1427	7.1509	7.1591	7.1673
40.0	104	6.9954	7.0036	7.0118	7.0200	7.0283	7.0365	7.0447	7.0529	7.0611	7.0693	7.0775	7.0857	7.0939	7.1022	7.1104	7.1186	7.1268	7.1350	7.1432	7.1514	7.1596
41.1	106	6.9878	6.9960	7.0042	7.0124	7.0207	7.0289	7.0371	7.0453	7.0535	7.0617	7.0699	7.0781	7.0864	7.0946	7.1028	7.1110	7.1192	7.1274	7.1356	7.1438	7.1520
42.2	108	6.9802	6.9884	6.9966	7.0048	7.0131	7.0213	7.0295	7.0377	7.0459	7.0541	7.0623	7.0705	7.0787	7.0869	7.0951	7.1033	7.1115	7.1197	7.1279	7.1361	7.1443
43.3	110	6.9726	6.9808	6.9890	6.9972	7.0054	7.0136	7.0218	7.0300	7.0382	7.0464	7.0546	7.0628	7.0710	7.0792	7.0874	7.0956	7.1038	7.1120	7.1202	7.1284	7.1366

TABLE 6.—*Specific gravities at 60°/60° F. (15.5°/15.5° C.) corresponding to degrees Baumé for liquids lighter than water.*

(Calculated from the formula, Specific gravity 60°/60° F.$=\frac{140}{130+\text{Deg. Bé}}$.)

Degrees Baumé.	Tenths of degrees Baumé.									
	0	1	2	3	4	5	6	7	8	9
18	0.9459	0.9453	0.9447	0.9440	0.9434	0.9428	0.9421	0.9415	0.9409	0.9402
19	.9396	.9390	.9383	.9377	.9371	.9365	.9358	.9352	.9346	.9340
20	.9333	.9327	.9321	.9315	.9309	.9302	.9296	.9290	.9284	.9278
21	.9272	.9265	.9259	.9253	.9247	.9241	.9235	.9229	.9223	.9217
22	.9211	.9204	.9198	.9192	.9186	.9180	.9174	.9168	.9162	.9156
23	.9150	.9144	.9138	.9132	.9126	.9121	.9115	.9109	.9103	.9097
24	.9091	.9085	.9079	.9073	.9067	.9061	.9056	.9050	.9044	.9038
25	.9032	.9026	.9021	.9015	.9009	.9003	.8997	.8992	.8986	.8980
26	.8974	.8969	.8963	.8957	.8951	.8946	.8940	.8934	.8929	.8923
27	.8917	.8912	.8906	.8900	.8895	.8889	.8883	.8878	.8872	.8866
28	.8861	.8855	.8850	.8844	.8838	.8833	.8827	.8822	.8816	.8811
29	.8805	.8799	.8794	.8788	.8783	.8777	.8772	.8766	.8761	.8755
30	.8750	.8745	.8739	.8734	.8728	.8723	.8717	.8712	.8706	.8701
31	.8696	.8690	.8685	.8679	.8674	.8669	.8663	.8658	.8653	.8647
32	.8642	.8637	.8631	.8626	.8621	.8615	.8610	.8605	.8600	.8594
33	.8589	.8584	.8578	.8573	.8568	.8563	.8557	.8552	.8547	.8542
34	.8537	.8531	.8526	.8521	.8516	.8511	.8505	.8500	.8495	.8490
35	.8485	.8480	.8475	.8469	.8464	.8459	.8454	.8449	.8444	.8439
36	.8434	.8429	.8424	.8419	.8413	.8408	.8403	.8398	.8393	.8388
37	.8383	.8378	.8373	.8368	.8363	.8358	.8353	.8348	.8343	.8338
38	.8333	.8328	.8323	.8318	.8314	.8309	.8304	.8299	.8294	.8289
39	.8284	.8279	.8274	.8269	.8264	.8260	.8255	.8250	.8245	.8240
40	.8235	.8230	.8226	.8221	.8216	.8211	.8206	.8202	.8197	.8192
41	.8187	.8182	.8178	.8173	.8168	.8163	.8159	.8154	.8149	.8144
42	.8140	.8135	.8130	.8125	.8121	.8116	.8111	.8107	.8102	.8097
43	.8092	.8088	.8083	.8078	.8074	.8069	.8065	.8060	.8055	.8051
44	.8046	.8041	.8037	.8032	.8028	.8023	.8018	.8014	.8009	.8005
45	.8000	.7995	.7991	.7986	.7982	.7977	.7973	.7968	.7964	.7959

TABLE 7.—*To obtain the specific gravity of turpentine at 15.5°/15.5° C. (60°/60° F.) from readings obtained at other temperatures with a Westphal balance or a hydrometer standardized at 15.5° C. (60° F.).*

Temperature when specific gravity is determined.		Observed specific gravity, as determined with a Westphal balance or a hydrometer, standardized to give specific gravity at 15.5° C. or 60° C.																				
° C.	° F.																					
10.0	50	0.8645	0.8655	0.8665	0.8675	0.8685	0.8695	0.8705	0.8715	0.8725	0.8735	0.8745	0.8755	0.8765	0.8775	0.8785	0.8795	0.8805	0.8815	0.8825	0.8835	0.8845
10.6	51	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750	.8760	.8770	.8780	.8790	.8800	.8810	.8820	.8830	.8840
11.1	52	.8636	.8646	.8656	.8666	.8676	.8686	.8696	.8706	.8716	.8726	.8736	.8746	.8756	.8766	.8776	.8786	.8796	.8806	.8816	.8826	.8836
11.7	53	.8631	.8641	.8651	.8661	.8671	.8681	.8691	.8701	.8711	.8721	.8731	.8741	.8751	.8761	.8771	.8781	.8791	.8801	.8811	.8821	.8831
12.2	54	.8627	.8637	.8647	.8657	.8667	.8677	.8687	.8697	.8707	.8717	.8727	.8737	.8747	.8757	.8767	.8777	.8787	.8797	.8807	.8817	.8827
12.8	55	.8622	.8632	.8642	.8652	.8662	.8672	.8682	.8692	.8702	.8712	.8722	.8732	.8742	.8752	.8762	.8772	.8782	.8792	.8802	.8812	.8822
13.3	56	.8618	.8628	.8638	.8648	.8658	.8668	.8678	.8688	.8698	.8708	.8718	.8728	.8738	.8748	.8758	.8768	.8778	.8788	.8798	.8808	.8818
13.9	57	.8613	.8623	.8633	.8643	.8653	.8663	.8673	.8683	.8693	.8703	.8713	.8723	.8733	.8743	.8753	.8763	.8773	.8783	.8793	.8803	.8813
14.4	58	.8609	.8619	.8629	.8639	.8649	.8659	.8669	.8679	.8689	.8699	.8709	.8719	.8729	.8739	.8749	.8759	.8769	.8779	.8789	.8799	.8809
15.0	59	.8604	.8614	.8624	.8634	.8644	.8654	.8664	.8674	.8684	.8694	.8704	.8714	.8724	.8734	.8744	.8754	.8764	.7774	.8784	.8794	.8804
15.5	60	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750	.8760	.8770	.8780	.8790	.8800
16.1	61	.8595	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735	.8745	.8755	.8765	.8775	.8785	.8795
16.7	62	.8590	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750	.8760	.8770	.8780	.8790
17.2	63	.8586	.8596	.8606	.8616	.8626	.8636	.8646	.8656	.8666	.8676	.8686	.8696	.8706	.8716	.8726	.8736	.8746	.8756	.8766	.8776	.8786
17.8	64	.8581	.8591	.8601	.8611	.8621	.8631	.8641	.8651	.8661	.8671	.8681	.8691	.8701	.8711	.8721	.8731	.8741	.8751	.8761	.8771	.8781
18.3	65	.8577	.8587	.8597	.8607	.8617	.8627	.8637	.8647	.8657	.8667	.8677	.8687	.8697	.8707	.8717	.8727	.8737	.8747	.8757	.8767	.8777
18.9	66	.8572	.8582	.8592	.8602	.8612	.8622	.8632	.8642	.8652	.8662	.8672	.8682	.8692	.8702	.8712	.8722	.8732	.8742	.8752	.8762	.8772
19.4	67	.8568	.8578	.8588	.8598	.8608	.8618	.8628	.8638	.8648	.8658	.8668	.8678	.8688	.8698	.8708	.8718	.8728	.8738	.8748	.8758	.8768
20.0	68	.8563	.8573	.8583	.8593	.8603	.8613	.8623	.8633	.8643	.8653	.8663	.8673	.8683	.8693	.8703	.8713	.8723	.8733	.8743	.8753	.8763
20.6	69	.8559	.8569	.8579	.8589	.8599	.8609	.8619	.8629	.8639	.8649	.8659	.8669	.8679	.8689	.8699	.8709	.8719	.8729	.8739	.8749	.8759
21.1	70	.8554	.8564	.8574	.8584	.8594	.8604	.8614	.8624	.8634	.8644	.8654	.8664	.8674	.8684	.8694	.8704	.8714	.8724	.8734	.8744	.8754
21.7	71	.8550	.8560	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.7800	.8710	.8720	.8730	.8740	.8750
22.2	72	.8546	.8556	.8566	.8576	.8586	.8596	.8606	.8616	.8626	.8636	.8646	.8656	.8666	.8676	.8686	.8696	.8706	.8716	.8726	.8736	.8746
22.8	73	.8541	.8551	.8561	.8571	.8581	.8591	.8601	.8611	.8621	.8631	.8641	.8651	.8661	.8671	.8681	.8691	.8701	.8711	.8721	.8731	.8741
23.3	74	.8537	.8547	.8557	.8567	.8577	.8587	.8597	.8607	.8617	.8627	.8637	.8647	.8657	.8667	.8677	.8687	.8697	.8707	.8717	.8727	.8737
23.9	75	.8532	.8542	.8552	.8562	.8572	.8582	.8592	.8602	.8612	.8622	.8632	.8642	.8652	.8662	.8672	.8682	.8692	.8702	.8712	.8722	.8732
		Corresponding specific gravity at 15.5°/15.5° C. or 60°/60° F.																				
.....	.....	0.8600	0.8610	0.8620	0.8630	.08640	0.8650	0.8660	0.8670	0.8680	0.8690	0.8700	0.8710	0.8720	0.8730	0.8740	0.8750	0.8760	0.8780	0.8780	0.8790	0.8800

[1] This table should be used only in connection with a Westphal balance or a hydrometer made to give specific gravity readings at 15.5°/15.5° C. or 60°/60° F.

FIG. 1.—DIPPING GUM FROM THE CUP.

FIG. 2.—A WELL-BUILT STILL SHED FOR LEVEL PLACES, WITH THE GUM PLATFORM PART OF THE UPPER DECK.

FIG. 1.—UNCOVERED GUM PLATFORM.

FIG. 2.—STILL SHED BUILT ON A SLOPE, MAKING ALL MOVEMENT OF THE RAW MATERIAL AND OF THE FINISHED PRODUCT DOWNHILL.

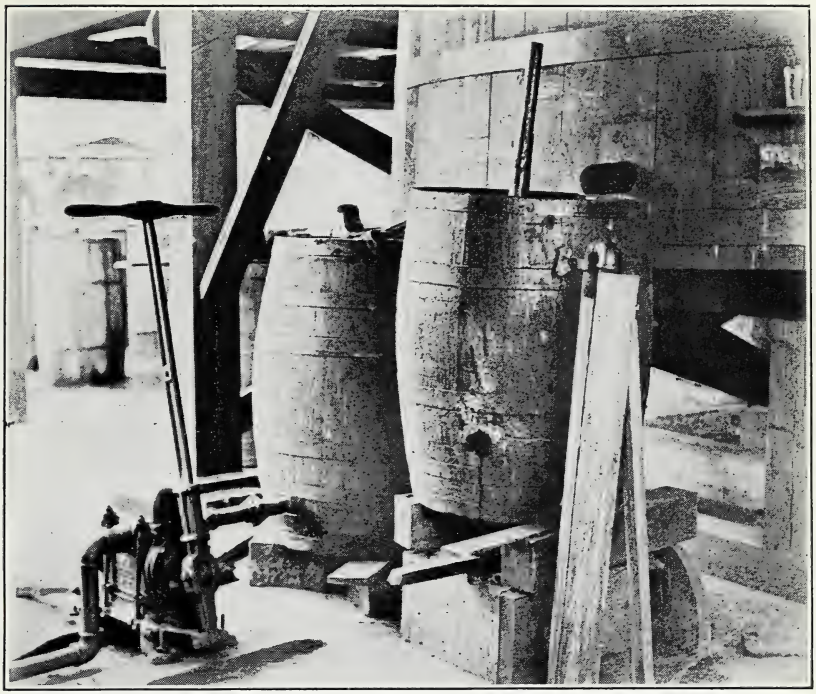

FIG. 1.—UNCOVERED TURPENTINE SEPARATOR AND RECEIVING BARREL, FROM WHICH THE TURPENTINE IS CONSTANTLY EVAPORATING.

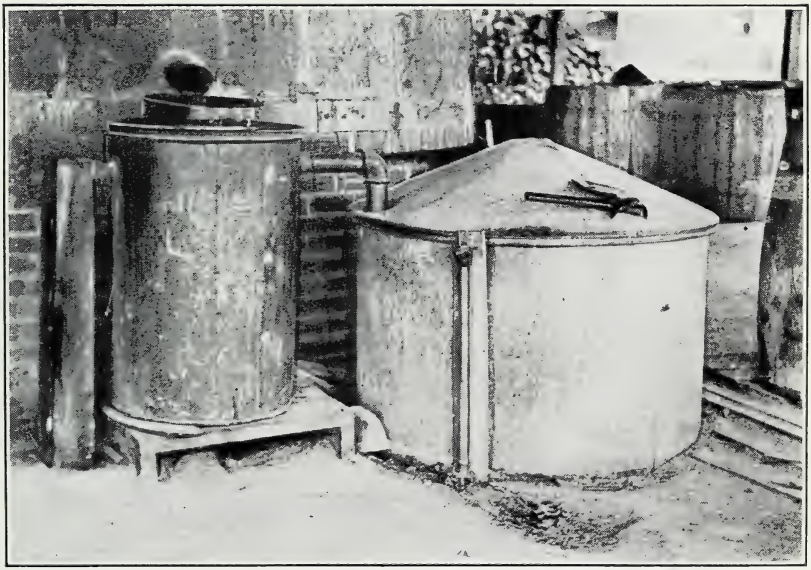

FIG. 2.—COVERED METAL TURPENTINE SEPARATOR AND RECEIVING TANK, IN WHICH EVAPORATION OF TURPENTINE IS REDUCED TO A MINIMUM.

TABLE 8.—*To obtain the specific gravity of turpentine at 15.5°/15.5° C. (60°/60° F.) from any readings obtained with a Westphal balance or a hydrometer standardized at 20° C. (68° F.).*

Temperature when specific gravity is determined.		Observed specific gravity reading, as determined with a Westphal balance or a hydrometer standardized to give specific gravity at 20°C. or 68° F.																			
°C.	°F.																				
13.9	57	0.8620	0.8630	0.8640	0.8650	0.8660	0.8670	0.8680	0.8690	0.8700	0.8710	0.8720	0.8730	0.8740	0.8750	0.8760	0.8770	0.8780	0.8790	0.8800	0.8810	0.8820
14.4	58	.8616	.8626	.8636	.8646	.8656	.8666	.8676	.8686	.8696	.8706	.8716	.8726	.8736	.8746	.8756	.8766	.8776	.8786	.8796	.8806	.8816
15.0	59	.8611	.8621	.8631	.8641	.8651	.8661	.8671	.8681	.8691	.8701	.8711	.8721	.8731	.8741	.8751	.8761	.8771	.8781	.8791	.8801	.8811
15.5	60	.8607	.8617	.8627	.8637	.8647	.8657	.8667	.8677	.8687	.8697	.8707	.8717	.8727	.8737	.8747	.8757	.8767	.8777	.8787	.8797	.8807
16.1	61	.8602	.8612	.8622	.8632	.8642	.8652	.8662	.8672	.8682	.8692	.8702	.8712	.8722	.8732	.8742	.8752	.8762	.8772	.8782	.8792	.8802
16.7	62	.8597	.8607	.8617	.8627	.8637	.8647	.8657	.8667	.8677	.8687	.8697	.8707	.8717	.8727	.8737	.8747	.8757	.8767	.8777	.8787	.8797
17.2	63	.8593	.8603	.8613	.8623	.8633	.8643	.8653	.8663	.8673	.8683	.8693	.8703	.8713	.8723	.8733	.8743	.8753	.8763	.8773	.8783	.8793
17.8	64	.8588	.8598	.8608	.8618	.8628	.8638	.8648	.8658	.8668	.8678	.8688	.8698	.8708	.8718	.8728	.8738	.8748	.8758	.8768	.8778	.8788
18.3	65	.8584	.8594	.8604	.8614	.8624	.8634	.8644	.8654	.8664	.8674	.8684	.8694	.8704	.8714	.8724	.8734	.8744	.8754	.8764	.8774	.8784
18.9	66	.8579	.8589	.8599	.8609	.8619	.8629	.8639	.8649	.8659	.8669	.8679	.8689	.8699	.8709	.8719	.8729	.8739	.8749	.8759	.8769	.8779
19.4	67	.8575	.8585	.8595	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735	.8745	.8755	.8765	.8775
20.0	68	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750	.8760	.8770
20.6	69	.8565	.8575	.8585	.8595	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735	.8745	.8755	.9765
21.1	70	.8561	.8571	.8581	.8591	.8601	.8611	.8621	.8631	.8641	.8651	.8661	.8671	.8681	.8691	.8701	.8711	.8721	.8731	.8741	.8751	.8761
21.7	71	.8556	.8566	.8576	.8586	.8596	.8606	.8616	.8626	.8636	.8646	.8656	.8666	.8676	.8686	.8696	.8706	.8716	.8726	.8736	.8746	.8756
22.2	72	.8552	.8562	.8572	.8582	.8592	.8602	.8612	.8622	.8632	.8642	.8652	.8662	.8672	.8682	.8692	.8702	.8712	.8722	.8732	.8742	.8752
22.8	73	.8547	.8557	.8567	.8577	.8587	.8597	.8607	.8617	.8627	.8637	.8647	.8657	.8667	.8677	.8687	.8697	.8707	.8717	.8727	.8737	.8747
23.3	74	.8543	.8553	.8563	.8573	.8583	.8593	.8603	.8613	.8623	.8633	.8643	.8653	.8663	.8673	.8683	.8693	.8703	.8713	.8723	.8733	.8743
23.9	75	.8538	.8548	.8558	.8568	.8578	.8588	.8598	.8608	.8618	.8628	.8638	.8648	.8658	.8668	.8678	.8688	.8698	.8708	.8718	.8728	.8738
24.4	76	.8534	.8544	.8554	.8564	.8574	.8584	.8594	.8604	.8614	.8624	.8634	.8644	.8654	.8664	.8674	.8684	.8694	.8704	.8714	.8724	.8734
25.0	77	.8529	.8539	.8549	.8559	.8569	.8579	.8589	.8599	.8609	.8619	.8629	.8639	.8649	.8659	.8669	.8679	.8689	.8699	.8709	.8719	.8729
25.6	78	.8524	.8534	.8544	.8554	.8564	.8574	.8584	.8594	.8604	.8614	.8624	.8634	.8644	.8654	.8664	.8674	.8684	.8694	.8704	.8714	.8724
26.1	79	.8520	.8530	.8540	.8550	.8560	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720
26.7	80	.8515	.8525	.8535	.8545	.8555	.8565	.8575	.8585	.8595	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715
		Corresponding specific gravity at 15.5/15.5° C. (60/60° F.).																			
.....	.....	0.8600	0.8610	0.8620	0.8630	0.8640	0.8650	0.8660	0.8670	0.8680	0.8690	0.8700	0.8710	0.8720	0.8730	0.8740	0.8750	0.8760	0.8770	0.8780	0.8790	0.8800

[1] This table should be used only when specific gravity is determined with a hydrometer or other apparatus designed for use at 20° C. (68°F.).

Table 5 has been compiled to show the weight of a gallon of turpentine at temperatures varying from 20° F. (−6.7° C.) to 110° F. (43.3° C.). Experiments performed in the Bureau of Chemistry have shown that the coefficient of expansion of turpentine at temperatures down to 5° C. (41° F.) is the same as at higher temperatures. It was assumed, therefore, that the coefficient of expansion would be practically the same at a slightly lower temperature, since this temperature (20° F.) is still far above the freezing point of turpentine.

In order to use Table 5 it is necessary to know the specific gravity of the turpentine at 15.5° C., or 60° F., which is usually and most easily determined by means of a Westphal balance or a hydrometer. Hydrometers are constructed to read in terms of specific gravity, in terms of density (p. 28), or in terms of Baumé degrees. To make possible the use in connection with Table 5 of a Baumé hydrometer, Table 6, giving the specific gravity at 15.5°/15.5° C. (60°/60° F.) corresponding to various Baumé readings, was compiled. Since the Baumé scale for light liquids in general use in the United States is based on the formula, degrees Bé $= \frac{140}{\text{sp. gr. } 60°/60° \text{ F.}} - 130$, it is evident that readings on a Baumé hydrometer bear a direct relation to specific gravity at 60°/60° F. only and must be taken at 60° F. (15.5° C.).

On the other hand, hydrometers reading in terms of specific gravity may be used at temperatures slightly above or below the base temperature for which they are calibrated without introducing a material error in the result. For example, if a hydrometer calibrated to give specific gravity at 20°/20° C. is used at 25° C., the resulting reading (disregarding a negligible error due to the expansion of the glass of which the hydrometer is made) will be the specific gravity at 25°/20° C. instead of 20°/20° C. Similarly, if a hydrometer calibrated to give specific gravity at 15.5°/15.5° C. is used at 20° C., the resulting reading will be the specific gravity at 20°/15.5° C. Tables 7 and 8 are used to determine the required specific gravity at 15.5°/15.5° C. (60°/60° F.) corresponding to readings obtained with a 15.5°/15.5° C. (60°/60° F.) or a 20°/20° C. (68°/68° F.) hydrometer, respectively, at various temperatures within the limit of negligible error. Table 7 may be used also in connection with a 15°/15° C. hydrometer, as the error thus introduced is negligible. If possible, it is always better to make the specific gravity determination at the temperature for which the hydrometer is calibrated.

If a hydrometer calibrated to read in terms of density is used as on a 15.5°/4° C. or a 20°/4° C. basis, the temperature of the liquid at the time of observing the density should be exactly 15.5° C. or 20° C., as the case may be. To convert the reading to specific gravity at 15.5°/15.5° C., add 0.0008 to the density at 15.5° C., or 0.0045 to the density at 20° C.

Example 1: To find the net weight of turpentine in a tank car containing 8,450 gallons, the average temperature of which is 88° F.—A sample taken from the tank has a specific gravity at 75° F. of 0.862 when measured with a hydrometer calibrated to give specific gravity at 20°/20° C. On consulting Table 8, on the line opposite 75° F. the value 0.8618, which is nearest the observed reading of 0.862, differing from it by 0.0002, is found. Reading down the column in which the figure 0.8618 was found, it is seen that this figure is equivalent to a specific gravity, at 15.5°/15.5° C. (60°/60° F.), of 0.8680. Since the observed reading of 0.8620 was greater by 0.0002 than the figure found in the table, the corresponding specific gravity at 15.5°/15.5° C. will also be greater by 0.0002, or 0.8682. Table 5 shows that at 88° F. the weight per gallon corresponding to a specific gravity, at 15.5°/15.5° C., of 0.8680 is 7.1219 pounds, and for a specific gravity of 0.8690 it is 7.1301 pounds. The difference in weight corresponding to a difference in specific gravity of 0.0010 is 0.0082 pounds, equivalent to 0.0016 pounds for a difference of 0.0002 in specific gravity. Then for a specific gravity of 0.8682, the weight per gallon at 88° F. is $7.1219+0.0016=7.1235$ pounds, and the total weight of turpentine in the car is 60,194 pounds (8450×7.1235).

Example 2: To determine the gallonage at the standard temperature of 15.5° C. (60° F.) of a tank car of turpentine containing 9,975 gallons at a temperature of 40° C., with a specific gravity of 31.2° Bé. at 60° F.—From Table 6 it is seen that a specific gravity of 31.2° Bé. is equivalent to 0.8685 at 60°/60° F. From Table 5 it is seen that such a turpentine at 40° F. weighs 7.3070 pounds per gallon, and at 60° F. would weigh 7.2318 pounds per gallon. Then the gallonage at 60° F. could be obtained by dividing the total net weight at 40° F. by the weight per gallon at 60° F. or $\frac{9975\times7.3070}{7.2318}$, equal to 10,079 gallons at 60° F

EFFECT OF STORAGE.

No marked change in the composition and properties of turpentine occurs when it is stored in completely filled tanks or in filled barrels for as long as from 12 to 18 months. When stored for some time in partially filled iron tanks, however, it has a tendency to become oxidized and changed in composition, which causes it to thicken, resulting in a higher specific gravity and boiling point, with correspondingly lower percentages distilling below any usually designated temperature. The specific gravity of turpentine at 15.5°/15.5° C. (the temperature at which specific gravity is usually determined) may increase to 0.885 or more when stored under these conditions, while the percentage distilling up to 170° C. may be less than 90. As a rule, when the specific gravity of a turpentine is more than 0.875

at 15.5° 15.5°C., less than 90 per cent will distill below 170° C. The specifications of the Government, the railroads, the American Society for Testing Materials, and a majority of the large users of turpentine require that at least 90 per cent shall distill below 170° C.

It is, therefore, to the interest of the producer, the consumer, the dealer, and the storage company to take all possible precautions to prevent oxidation or thickening. This can be done by keeping the tanks full and by frequently replacing old turpentine as it is drawn from the tank with fresh stock. Turpentine should not remain long in the tanks, especially if they are only partially filled, nor should air be pumped up through the turpentine in a tank that is filled from below, when turpentine is pumped in.

ADULTERATION.

A wide difference exists between the price of turpentine and that of the light oils, such as benzine, kerosene, "varnish makers' and painters' naphtha," and "mineral spirits," derived from crude petroleum and benzol (also sometimes called benzene, which is not the same as benzine), xylol, and so-called solvent or coal-tar naphtha, derived from coal tar. These oils, which usually are comparatively cheap, are often used to adulterate the more expensive turpentine. The Bureau of Chemistry frequently finds as little as 5 per cent of such an adulterant in turpentine, although the percentage of mineral oil in samples of adulterated turpentine bought at paint, hardware, and general stores ordinarily runs much higher. Even as little as 5 per cent adulteration is profitable to a dealer doing a large volume of business. With turpentine selling at $1.50 a gallon and the substitutes at 30 cents a gallon, an adulteration of 5 per cent costs the buyer in actual outlay $3.00 a barrel (the difference between the actual value of 2½ gallons of turpentine and of the cheaper adulterant).

For some years very few cases of adulteration on the part of producers of turpentine have come to the attention of the Bureau of Chemistry. Less than 4 per cent of the samples taken from producers' shipments have been found to be adulterated. In the majority of such cases the samples were taken because adulteration was suspected by the State inspector who examined the turpentine on its arrival at the primary market.

From 10 to 20 per cent of the samples purchased by the Bureau of Chemistry at different times during recent years from retail paint, hardware, and general stores have been found adulterated. Some of this was done by unscrupulous wholesalers who furnished the turpentine to the dealers, and some by dishonest retail dealers. Under present conditions, it is not always possible to determine where the fault lies. No matter who is guilty in such cases, the fact remains that dishonest profits are made at the expense of the buying public,

while, at the same time, every gallon of mineral or coal tar oil sold as turpentine helps to reduce the legitimate price of pure turpentine.

Neither the honest storekeeper who buys supposedly pure turpentine, a barrel or so at a time, nor the individual user who purchases it by the quart or gallon is in a position to protect himself and the work he has under way against such frauds, as it rarely pays to have an examination made to determine whether or not the turpentine is pure.

Only 16 States have laws prohibiting the shipment and sale of adulterated turpentine or turpentine substitutes as pure turpentine, and such laws do not cover interstate shipments. The Federal Food and Drugs Act covers only *interstate shipments of turpentine which is put up and sold for medicinal purposes.* Some other agency is needed to protect the producer, the honest dealer, and the small user of turpentine against the continued practice of adulteration, most of which, it is believed, occurs on shipments which go from one State to another, which can not be reached under present laws.

SIMPLE TESTS FOR ADULTERATION.

Since the individual rarely has occasion and the producer is seldom in a position to make all the tests enumerated in the specifications, it may be stated that the producer, knowing the purity of his product, need examine only to determine whether the turpentine is "standard" in color and whether it meets the specifications for specific gravity and distillation. Should the specific gravity at 15.5°/15.5° C., when carefully taken with an accurate hydrometer or spindle, be between 0.862 and 0.870 (32.4° to 30.9° Bé.), as is the case with nearly all American gum spirits of turpentine, it may safely be concluded that the sample will meet the requirements as to distillation. Should the specific gravity be found near the limits of the specifications given on page 43, the sample should be examined by a competent chemist qualified to test turpentine. In the case of fresh turpentine which has not been scorched in making, become oxidized by standing in a tank, or been contaminated with oxidized turpentine, no testing is needed. Such turpentine will always pass the specified requirements.

When turpentine is adulterated to the extent of 10 per cent or more, a careful observer familiar with turpentine can usually determine the fact by one or more of the following simple tests:

Odor.—The presence of kerosene, gasoline, benzol, or solvent naphtha is usually revealed by its odor. Wood turpentine is best distinguished from gum spirits by its odor. The odors of these materials can not be described; they can be learned only by actual trial and experience. Lack of the characteristic turpentine odor is good ground for a careful test to determine the purity of the sample.

Grease spot.—Pour a little of the suspected turpentine on a piece of white writing paper. If the bulk of the sample evaporates rapidly from the paper, leaving a greasy spot which evaporates very slowly or not at all, the turpentine is probably adulterated with kerosene or heavy solvent naphtha, or contains a large percentage of heavy turpentine which will not distill below 170° C. The odor of the grease spot often determines the nature of the adulterant. Greasy spots around bung or spigot holes of turpentine barrels are also indicative of these adulterants.

Bead.—When a perfectly clean dry bottle is partly filled with turpentine and violently shaken for a moment the bead or foam that forms will immediately pass away if the turpentine is pure and fresh. If the foam persists for 5 seconds or more, the turpentine probably is adulterated or old.

Evaporation test.—Set a 5-inch watch glass near an open window where a gentle air current can blow across it. Carefully place in it 5 cc. (a tablespoonful) of the turpentine, so that the glass does not become wet with the turpentine beyond the edge of the surface of the liquid. Then carefully pipette or dip out 2 cc., or about half of it (a scant teaspoonful). Observe the rim of the turpentine film after 3 hours. If the rim is continuous or more or less regular in outline, the turpentine is probably pure. If, however, the rim is made up of a chain of distinct drops or beads, or if the liquid appears to flow back to the center of the glass in distinct streams, it probably is adulterated with mineral oil or is an old turpentine of high specific gravity. The unevaporated residue will also smell of mineral oil if kerosene or any other oil which is less volatile than turpentine has been used as an adulterant.

Needless to state, if all these simple tests are definite, there can be little doubt that the turpentine is adulterated. When these tests are negative, however, it can not be safely assumed that it is not adulterated to a small extent or very carefully to a large extent with a specially prepared turpentine adulterant or substitute.

STATE LAWS GOVERNING TRANSACTIONS IN TURPENTINE.

State laws governing the sale of turpentine are in effect in 16 States—California, Colorado, Florida, Georgia, Illinois, Iowa, Kansas, Massachusetts, Michigan, Mississippi, New Jersey, New York, Ohio, Pennsylvania, Vermont, and Wisconsin.

In Florida, Georgia, Iowa, Massachusetts, and Michigan the laws governing transactions in turpentine apply to no other material. In the other States such transactions are covered by the laws pertaining to paint or linseed oil. The number and date of each act, with a brief outline of the provisions pertaining to turpentine, follow:

Florida (ch. 5115, No. 10, Acts of 1903, p. 44).—Known as the pure spirits of turpentine act. Defines turpentine or "spirits of turpen-

tine" as the pure distillate from turpentine gum or scrape of pine trees. Defines wood turpentine or "wood spirits of turpentine" as the pure distillate resembling "spirits of turpentine" obtained by the distillation of wood. Defines as "adulterated spirits of turpentine" any spirits of turpentine to which any foreign oil or other substance or any "wood spirits of turpentine" has been added. Any "wood spirits of turpentine" mixed in any proportion with any foreign substances or adulterants is defined as "adulterated wood spirits of turpentine." Requires the proper labeling or marking, as quoted above, of every container in which turpentine is sold, shipped, or manufactured for sale or shipment.

Georgia (*No. 396, Acts of 1903, p. 77*).—Same as the Florida law.

Iowa (*34 G. A., ch. 111, Acts of 1911, p. 124*).—Defines turpentine, oil of turpentine, spirits of turpentine, or "turps" as consisting wholly of the oil distilled from the oleoresinous exudation of coniferous trees (pine gum). Sets physical and chemical standards for pure turpentine. Requires every container to be marked to show the true nature of contents. Any substitute for, compound or mixture of, turpentine with any other product must be labeled and sold as "substitute for oil of turpentine." If the word "turpentine" is used other than in the name, the true name of each and every ingredient must be specified in the order of their proportions.

Massachusetts (*ch. 266, Acts of 1911, p. 223*).—Makes unlawful the sale, exposure for sale, or possession of, with intent to sell, any turpentine, mixed or adulterated in any way with any other product, unless the same is clearly labeled "Adulterated spirits of turpentine." Any trade name for such material must not contain the word turpentine, nor any name or device illustrating or suggesting turpentine. Any person selling adulterated, compounded, or substitute turpentine must inform the purchaser at the time of sale that the article is not pure spirits of turpentine.

The paint law, chapter 531, Acts of 1908, also makes unlawful the sale of any turpentine labeled or marked in such manner as to deceive or tend to deceive, any person of its nature or composition.

Michigan (*No. 175, Acts of 1911, p. 298*).—Forbids the sale of any product under the name of turpentine, or a name composed of a part or parts of the word turpentine, which does not consist wholly of pure gum spirits of turpentine. Defines turpentine, wood turpentine, and adulterated turpentine as given under the Florida law. Any mixture of gum turpentine with wood turpentine or any foreign or other substance can be sold only as "adulterated turpentine," and must be so labeled. Requires every package containing adulterated turpentine or wood turpentine to be labeled.

California (*included in the general paint bill, ch. 190[illegible], p. 852*).—Forbids the sale of adulterated turpentine or substitute turpentine as pure turpentine. "Any article shall be deemed adulterated

within the meaning of this act: (1) In case of oils, turpentine, alcohol or other vehicles: (*a*) If it contains any other substance or ingredient different from the article under the name of which it is offered for sale or sold; (*b*) if any substance has been mixed with it so as to lower, depreciate, or injuriously affect the quality, strength, or purity of the article; (*c*) if any inferior or cheaper substance has been substituted wholly or in part; (*d*) if it is an imitation, or is sold under the name of any other product."

Colorado (included in the general oil bill, ch. 126, Acts of 1915, p. 367).—The section pertaining to turpentine is similar to the Michigan law. Also has a section requiring any painter who enters into a contract or agreement to paint any building or structure to use pure turpentine and pure linseed oil in his paints, unless he gives specific notice to the contrary in writing before entering into said contract or agreement. The law accepts as standard the tests of the American Society for Testing Materials, or those of the Bureau of Chemistry, U. S. Department of Agriculture.

Illinois (included in the paint bill, senate No. 340, Laws of 1917, p. 769).—Similar to the Iowa law, except that either pure gum spirits of turpentine or pure wood turpentine may be sold as turpentine, oil of turpentine, or "turps." Adopts as standard the latest specifications of the American Society for Testing Materials.

Kansas (included in the linseed oil bill, house bill 184, ch. 179, Acts of 1911, p. 305).—Defines turpentine or spirits of turpentine as in Florida law. Requires that every container in which turpentine is sold be labeled to show the true nature or name of contents. Adulterated, compounded, or substitute turpentine must be labeled in plain English to show the actual proportion of turpentine and other ingredients present. They must not be sold as turpentine or under any name or device consisting of a part of the word turpentine or illustrating or suggesting turpentine.

Mississippi (included in the paint bill (house bill 380), ch. 197, Acts of 1918, p. 246).—Requires every container, wholesale or retail, in which paint or turpentine is sold to be labeled to show the actual proportion of pure turpentine contained. Under this requirement, adulterated turpentine must show on the label the actual percentage by volume of pure turpentine present. In the interpretation by the State chemist, who is empowered to enforce the bill, the term "turpentine" means only pure gum turpentine. "Wood turpentine" must be labeled as such. Adulterated products should show on the label not only the proportion of pure gum turpentine, but also the proportion of foreign oil (petroleum or other).

New Jersey (included in the linseed oil bill, ch. 264, Acts of 1910, p. 429).—Defines turpentine as in the Florida law. Mixtures of turpentine with other substances must be labeled "Adulterated spirits of

turpentine" and show the true name and amount of adulterant contained therein. Requires notification of the purchaser at the time of sale, as in the Massachusetts law.

New York (included in the amendment to the agricultural law of 1893, being ch. 584, laws of 1906, p. 1529).—Similar to the New Jersey law.

Ohio (included in the supplement, sec. 6331–1, to sec. 6331 of the General Code, being senate bill No. 204, laws of 1910, p. 239).—Similar to the Massachusetts law.

Pennsylvania (included in the paint law, No. 297, Acts of 1915, p. 665).—Similar to the Massachusetts paint law, chapter 531, Acts of 1908. Mislabeling or misbranding is committed if the article is an imitation of, or sold or offered for sale under the name of, another article, or if the label is false or misleading in any particular.

Vermont (included in the paint bill, No. 123, Public Acts of 1908, p. 115).—Requires adulterated or substitute turpentine to be plainly labeled "Substituted."

Wisconsin (included in the act creating sec. 1636–1 of the statutes relating to linseed oil, turpentine, and paint, being ch. 532, Acts of 1909, No. 593, A, p. 732).—Defines turpentine, spirits of turpentine, or oil of turpentine, and also wood turpentine or wood spirits of turpentine, as in the Florida law. Forbids the sale "as and for" either of these, anything except the pure article as defined, also the sale of any turpentine except under its true name as outlined. Every container must be plainly labeled with the true name of the contents.

NEED FOR UNIFORM SPECIFICATIONS AND METHODS OF TESTING.

It is the univeral experience that definite specifications are necessary in the purchase of all materials which are easily and profitably adulterated. They are essential to protect the buyer against delivery of low-grade materials and to protect the seller against competition with venders of lower-priced articles.

The specifications upon which turpentine is bought and sold in the primary naval stores markets of the country are those implied or stated in the several State laws and in the rules and regulations of the boards of trade and chambers of commerce of the primary markets. The requirements are that the turpentine shall be pure, and standard or better in color. No details as to what tests shall be applied to determine purity or color are laid down, nor are methods of conducting the tests described. The specifications given on pages 43 to 49 embrace the recognized requirements which determine whether or not a turpentine is pure, and describe in detail the methods of making the required tests. Methods for the correct sampling of the turpentine are given also. Needless to say, it requires much more space to describe these things clearly than to simply state that "the turpentine shall be pure, and standard or better in color,"

which can be determined by only the intelligent and accurate use of the procedures described in detail on pages 43 to 48 of this bulletin.

Large buyers of turpentine, such as paint and varnish makers, the several Government departments, and State and city purchasing agents, have for years bought turpentine on specifications which have been more or less specific and detailed. Rarely, however, have any two sets of specifications or the methods of testing of different buyers been identical, while too frequently the methods of testing have been seriously erroneous. The accompanying specifications (pp. 43–49) have been prepared as a guide in the purchase of turpentine, by one of the largest users of turpentine—the Federal Government in all its branches. The United States Department of Agriculture has furnished most of the data on which the specifications are based, and has taken the active part in formulating them. The specifications, of course, are suitable for and applicable to all turpentine designed for the purposes for which it is usually employed, such as paint and varnish thinner, in polishes, pharmaceuticals, calico printing, etc., and are issued for the information of the turpentine producing and consuming industries.

All recently made turpentine will comply with these specifications. Only that which has been stored in partially filled containers for a long time may not comply with those for specific gravity and distillation, for the reason that on long storage in partly filled containers turpentine takes up oxygen, becomes thicker and heavier, and leaves a larger residue on drying or when distilled. Nevertheless, such partially oxidized turpentine may be and usually is suitable for thinning paints and varnishes which are to be used in hot weather or hot climates, or those which are used out of doors under favorable drying conditions or where slow drying is desired.

Fresh turpentine will always meet these specifications. The producer who does not adulterate his turpentine and who keeps his storage tanks full or keeps turpentine moving through them need have no fear that it will fail to comply with these specifications. It is suggested that the producer or dealer make a practice of always selling the stock which has been on hand longest, thus avoiding danger of excessive oxidation.

The following specifications probably are the most complete that have ever been prepared for turpentine, and may appear, to dealers and producers especially, lengthy and likely to complicate materially transactions in turpentine. As previously stated, this need not be feared when the turpentine is pure and has been stored with proper care. The specifications proper, which are very simple, are covered in section 1, page 43; the rest cover the directions for taking samples (a highly important matter, since if the sample is not representative the results of examination will be misleading),

and include a description of the methods of testing, together with a statement on the basis of sale. All of these are essential in any complete specifications to insure proper samples and accurate examination. Especially are they necessary in case of dispute involving either the quality or quantity of a delivery of turpentine.

The specifications are equally fair to the producer and the consumer. Their detail and length are necessary for a fair action on those turpentines which may be very close to the limits of the specifications and where errors in sampling or in analysis and testing may cause the rejection of a good turpentine or the acceptance of an adulterated or unsuitable turpentine.

RECOMMENDED SPECIFICATIONS FOR TURPENTINE (GUM SPIRITS AND WOOD TURPENTINE).[1]

1. GENERAL.

These specifications apply both to the turpentine which is distilled from pine oleoresins, commonly known as gum spirits or spirits of turpentine, and to turpentine, commonly known as wood turpentine, which is obtained from resinous wood, whether by steam or by destructive distillation. When ordering under these specifications, the purchaser shall specify whether (*a*) gum spirits or (*b*) wood turpentine is desired. When wood turpentine is specified, it may be stated whether steam or destructively distilled wood turpentine shall be furnished.

Turpentine shall be pure and conform to the following requirements:

APPEARANCE.—Shall be clear and free from suspended matter and water.

COLOR.—Shall be "standard" or better.

ODOR.—Shall be characteristic of the variety of turpentine specified and, if desired, shall conform to the odor of the sample agreed upon.

	Maximum.	Minimum.
Specific gravity, 15.5°/15.5° C.	0.875	0.862
Refractive index at 20° C.	1.478	1.468
Residue after polymerization with 38 *N* H_2SO_4:		
Gum spirits—		
Volume (per cent)	2.0	
Refractive index at 20° C.		1.500
Wood turpentine—		
Volume (per cent)	2.5	
Refractive index at 20° C.		1.495
Initial boiling point at 760 mm. pressure (° C.)	160	150
Distilling below 170° C. at 760 mm. pressure (per cent)		90

2. DETECTION AND REMOVAL OF SEPARATED WATER.

Draw a portion by means of a glass or metal container with a removable stopper or top, or with a "thief," from the lowest part of the container, or by opening the bottom valve of the perfectly level tank car. If water is found to be present, draw it all out, record the quantity, and deduct it from the total volume of liquid delivered.

[1] Prepared and recommended by the U. S. Interdepartmental Committee on Paint Specification Standardization, October 27, 1919, P. H. Walker, Bureau of Standards, chairman; H. E. Smith, U. S. Railroad Administration, secretary. This committee was appointed at the suggestion of the Secretary of Commerce, and consisted of representatives of the War, Navy, Agriculture, Interior, Post Office, Treasury, and Commerce Departments, the Railroad Administration, the Panama Canal, and the Educational Bureau of the Paint Manufacturers Association of the United States. The committee submitted a preliminary draft of the specifications to a large number of representatives of the naval-stores industries and the paint and varnish industries, and gave careful consideration to the replies which were received in time.

3. SAMPLING.

The method of sampling given under (*a*) should be used whenever feasible. When method (*a*) is not applicable, method (*b*), (*c*), or (*d*) is to be used according to the special conditions that obtain.

(*a*) **While loading tank car or while filling containers for shipment.**—Samples shall be drawn by the purchaser's inspector at the discharge pipe where it enters the receiving vessel or vessels. The composite sample shall be not less than 5 gallons and shall consist of small portions of not more than 1 quart each, taken at regular intervals during the entire period of loading or filling.

The composite sample thus obtained shall be thoroughly mixed, and from it three samples of not less than 1 quart each shall be placed in clean, dry glass bottles or tin cans, which must be nearly filled with the sample and securely stoppered with new, clean corks or well-fitting covers or caps. These shall be sealed and distinctly labeled by the inspector; one shall be delivered to the buyer, one to the seller, and the third held for check in case of dispute.

(*b*) **From loaded tank car or other large vessel.**—The composite sample taken shall be not less than 5 gallons and shall consist of numerous small samples of not more than 1 quart each, taken from the top, bottom, and intermediate points by means of a metal or glass container with removable stopper or top. This device, attached to a suitable pole, is lowered to the various desired depths when the stopper or top is removed, and the container allowed to fill. The sample thus obtained is handled as in (*a*).

(*c*) **Barrels and drums.**—Barrels and drums shall be sampled after gaging contents. Five per cent of the packages in any shipment or delivery shall be represented in the sample. Thoroughly mix the contents of each barrel to be sampled by stirring with a clean rod and withdraw a portion from about the center by means of a "thief" or other sampling device. The composite sample thus obtained shall be not less than 3 quarts, shall consist of equal portions of not less than one-half pint from each package sampled, and shall be handled as in (*a*). Should the inspector suspect adulteration, he shall draw the samples from the suspected packages.

(*d*) **Small containers, cans, etc., of 10 gallons or less.**—These should be sampled, while filling, by method (*a*) whenever possible; but in case this is impossible the composite sample taken shall be not less than 3 quarts. This shall be drawn from at least five packages (from all when fewer), and in no case from less than 2 per cent of the packages. The composite sample thus taken shall be thoroughly mixed and subdivided as in (*a*).

4. LABORATORY EXAMINATION.

Samples will, in general, be tested by the following methods; but the purchaser reserves the right to apply any additional tests or use any available information to ascertain whether the material meets the specifications:

(*a*) **Appearance.**—Examine to determine compliance with the specifications.

(*b*) **Color.**—Fill a 200-mm. perfectly flat-bottomed colorimeter tube, graduated in millimeters, to a depth of from 40 to 50 mm. with the turpentine to be examined. Place the tube in a colorimeter and place on or under it a No. 2 yellow Lovibond glass. Over or under a second graduated tube in the colorimeter place a No. 1 yellow Lovibond glass and run in the same turpentine until the color matches as nearly as possible the color in the first tube. Read the difference in depth of the turpentine in the two tubes. If the difference is 50 mm. or more, the turpentine is "standard" or better.

(*c*) **Odor.**—Determine by comparison with several samples of known purity, which have been kept in the dark in completely filled, well-stoppered bottles and are free from separated water.

(*d*) **Specific gravity.**—Determine at 15.5°/15.5° C., in a pycnometer accurately standarized and having a capacity of at least 25 cc., or by any other equally accurate method.

(*e*) **Refractive index.**—Determine refractive index at 20° C. with an accurate instrument. When the refractive index is determined at any other temperature, the readings obtained shall be corrected to 20° C. by adding to or by subtracting from the actual reading 0.00045 for each degree centigrade that the temperature at which the determination was made is, respectively, above or below 20° C.

(*f*) **Distillation.**—Apparatus.[1]—*Condenser.*—The type of apparatus (fig. 6) adopted by the American Society for Testing Materials for the distillation of paint thinners other than turpentine, substituting for the thermometer there described an immersed thermometer such as is described below, is preferred. In case the A. S. T. M. distillation apparatus is not available, use an ordinary straight glass-tube condenser, about 22 inches long, with 16 inches in contact with the cooling water. The end of the condenser tube should be fitted with an adapter or should be bent down to a

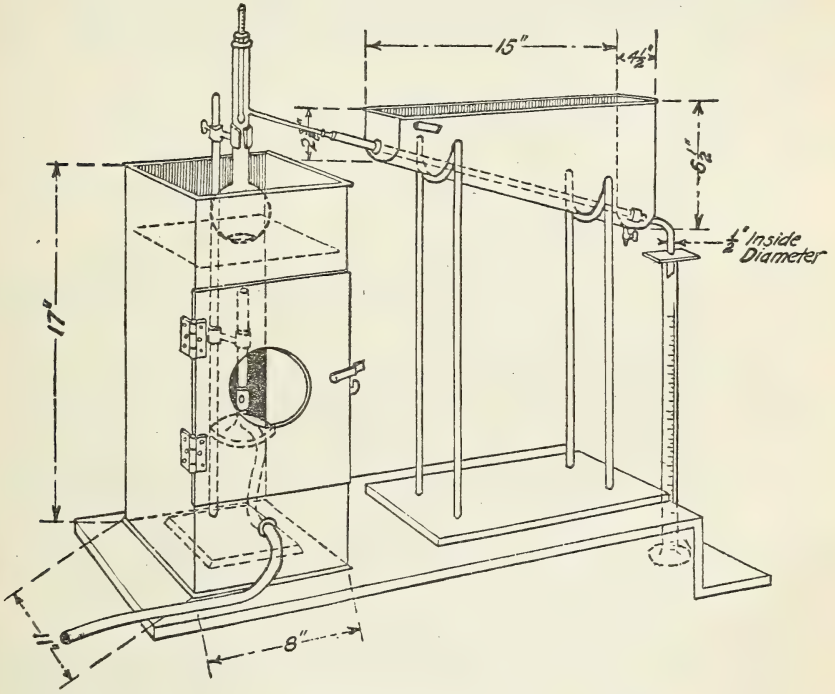

Fig. 6.—Distillation apparatus.

nearly vertical position, and the tip should be cut off or ground down at an acute angle. The tip should extend a short distance into the receiving cylinder.

Flask.—Comparable results can be obtained only by using flasks of the same dimensions. The distilling flask used shall be the standard Engler flask, as used for petroleum distillation, having the following dimensions: Diameter of bulb, 6.5 cm.; cylindrical neck, 15 cm. long, 1.6 cm. internal diameter; side or vapor tube, 10 cm. long, 0.6 cm. external diameter, attached to neck at an angle of 75°, so that when the flask contains its charge of 100 cc. of oil the surface of the liquid shall be 9 cm. below the bottom of the junction of the side tube and neck.

Support for flask.—Support the flask on a plate of asbestos 20 cm. in diameter, having an opening 4 cm. in diameter in its center, and heat with an open flame. Surround the flask and burner with a shield to prevent fluctuation in the temperature of the neck of the flask. Or, support the flask in a metal cup, 15 to 20 cm. in diameter,

[1] A. S. T. M. Standards (1918), p. 607.

containing high-boiling mineral oil or glycerin and fitted with a concave cover having in the center a circular opening 5½ to 6 cm. in diameter. In all cases take the necessary precautions to prevent fluctuation in temperature in the neck of the flask.

Thermometer.—The thermometer used for turpentine distillation shall conform to the following specifications:

It shall be graduated from 145° to at least 200° C. in 0.2° intervals. Thermometers graduated above 200° C. may be used, provided they also comply with the following requirements: Length, bottom of thermometer to 175° mark, not more than 8 nor less than 6.5 cm.; length, top of bulb to 145° mark, not less than 1.5 cm.; length, 145° to 175° mark, not more than 6 cm.

The thermometer shall be made of suitable thermometric glass and thoroughly annealed, so that the scale errors will not increase after continued heating.

The thermometer shall be filled above the mercury with an inert gas, with sufficient pressure above the mercury column to prevent breaking of the column. It shall have a reservoir at the top, so that the pressure will not become excessive at the highest temperature.

Every fifth graduation shall be longer than the intermediate ones, and the marks shall be numbered at each interval of 5°. The graduation marks shall be clear-cut and fine and the numbering clear-cut and distinct.

The error at any point on the scale shall not exceed ±0.5° C. when tested for total immersion of the mercury column.

Receiving cylinder.—Collect the distillate in an accurately graduated 50 or 100 cc. cylinder. The so-called normal or precision cylinder of 50 cc. capacity, having an internal diameter of 1.5 cm. and graduated in 0.2 cc., is preferred. If a cylinder with larger inside diameter is used, a pasteboard cover should be placed over the top and surround the condenser tube.

Operation.—Place 100 cc. of the turpentine and several small pieces of pumice (or glass) in the distilling flask, fit the thermometer so that the top of the mercury bulb is level with the bottom of the side tube, and the 175° C. (347° F.) mark is below the cork. Place the flask in position on the asbestos board or oil bath and connect with the condenser. Apply the heat cautiously at first, and, when distillation begins, regulate the heat so that the turpentine distills at the rate of not less than 4 nor more than 5 cc. per minute (approximately two drops per second). The initial boiling point is the thermometer reading at the instant when the first drop falls from the end of the condenser. Discontinue distillation when the temperature reaches 170.0° C. (338° F.), or an equivalent thereof, depending on the atmospheric pressure, as outlined below; let the condenser drain and read the percentage distilled.

The percentage distilled below successive selected temperatures and the temperature at which each successive 10 cc. distills may also be determined, if desired, making the necessary correction of the temperature for variations in atmospheric pressure.

Correction for variation in atmospheric pressure.—Since distillation results are comparable only when obtained under exactly the same pressure conditions, turpentine shall be distilled at that pressure which, at room temperature, is equivalent to a pressure of 760 mm. of mercury at 0° C. Whenever the atmospheric pressure after correcting to 0° C. is other than 760 mm., a correction must be made. Since alteration of the pressure in the distilling system requires rather complicated apparatus, it is simpler to alter the temperature observation points to correspond to the prevailing pressure.

To determine what the atmospheric pressure at the prevailing room temperature, or at the temperature of the barometer, would be at 0° C., read the barometer and thermometer alongside when about to begin distillation. Refer to Table 9, page 49. Under the column nearest the observed pressure reading, and on the line nearest the observed temperature of the barometer will be found the correction which must

be subtracted from the observed pressure reading to obtain the equivalent, or true, reading at 0° C.

The distilling temperature of turpentine is affected plus (+) or minus (—) 0.057° C. for each millimeter variation of the barometer above or below the normal 760 mm. at 0° C.[1] If the barometer reading, after correcting to 0° C., is below 760 mm., the turpentine will distill at a slightly lower temperature than under normal pressure. Therefore, the temperature recorded at the beginning of distillation (and any others observed during the course of the distillation) must be corrected to get its equivalent at normal pressure. The final temperature observation point (170° C., of the specifications) must be altered accordingly to get its equivalent at the pressure (corrected to 0° C.) at which distillation is made.

For example, if the barometer reading, after correcting to 0° C., is 750 mm., the correction of the observed initial distilling temperature will be 0.057×10 mm.$=0.6°$ C., approximately. If the reading of the thermometer when the turpentine begins to distill is 155.6° C., the corrected initial distilling temperature will be $155.6° + 0.6° = 156.2°$ C. Furthermore, the temperature observation point at the end of distillation (170.0° C. at 760 mm.) must be altered to the same extent. Since the turpentine is distilling 0.6° C. below what it would at normal pressure, distillation must be discontinued at 0.6° C. below the specified limit of 170.0° C. to determine the percentage distilling below 170.0° C.

If the barometer reading corrected to 0°C. is above 760 mm., subtract the temperature correction from the observed thermometer reading to determine the initial distilling point, and continue distillation to 170.0° C. plus the correction to determine the percentage distilling below 170.0° C.

(*g*) **Polymerization.**—Place 20 cc. of 38 *N* (equivalent to 100.92 per cent H_2SO_4) sulphuric acid in a graduated, narrow-necked Babcock flask, stopper, and place in ice water to cool. Add slowly, from a pipette, 5 cc. of the turpentine to be examined. Gradually mix the contents, keeping warm, but being very careful that the temperature does not rise above 60° C. When the mixture no longer warms up on shaking, agitate thoroughly and place the flask in a water bath and heat at 60° to 65° C. for not less than 10 minutes, keeping the contents of the flask thoroughly mixed by vigorous shaking for one-half minute each time, six times during the period. Do not stopper the flask after the turpentine has been added, as it may explode. Cool to room temperature, fill the flask with concentrated sulphuric acid until the unpolymerized oil rises into the graduated neck and centrifuge from four to five minutes at not less than 1,200 r. p. m., or for 15 minutes at 900 r. p. m., or allow to stand, lightly stoppered, for 12 hours. Calculate the percentage, note the consistency and color, and determine the refractive index (at 20° C.) of the unpolymerized residue. The consistency should be viscous and the color straw or darker.

Reagent for testing.—In a weighed glass-stoppered bottle (the regular 2½-liter acid bottle is of a convenient size) mix ordinary concentrated sulphuric acid (sp. gr. 1.84) with fuming sulphuric acid. If the fuming acid used contains 50 per cent excess SO_3, the ratio of one part, by weight, of the former to three-fourths of a part, by weight, of the latter will give a mixture slightly stronger than the required strength. To determine the exact strength of this mixture in terms of H_2SO_4, weigh exactly, in a weighing pipette of about 10 cc. capacity, approximately 20 grams of the acid. Allow it to flow down the sides of the neck into a 1,000-cc. volumetric flask containing about 200 cc. of distilled water. When the pipette has drained, wash all traces of the acid remaining in the pipette into the flask, taking precautions to prevent loss of SO_3, and make up to the mark. Titrate 20-cc. portions, drawn from a burette, against half normal alkali. Calculate the concentration in terms of the percentage of H_2SO_4 in the sample taken.

[1] Landolt-Börnstein Physikalisch-Chemische Tabellen, Ed. 4, Table 127, p. 435.

In the same way determine the percentage of H_2SO_4 in the stock of ordinary concentrated acid (sp. gr. 1.84). From these data calculate the quantity of the latter which must be added to the quantity of mixed acid in the weighed bottle to bring it to a concentration, in terms of H_2SO_4, of 100.92 per cent.

After adjusting the concentration by the addition of the ordinary sulphuric acid, thoroughly shake the bottle of mixed acid and again determine its concentration. The allowable variation is ± 0.05 per cent H_2SO_4. Finally as a check run a polymerization test on gum turpentine known to be pure. The residue should fall below 2 per cent.

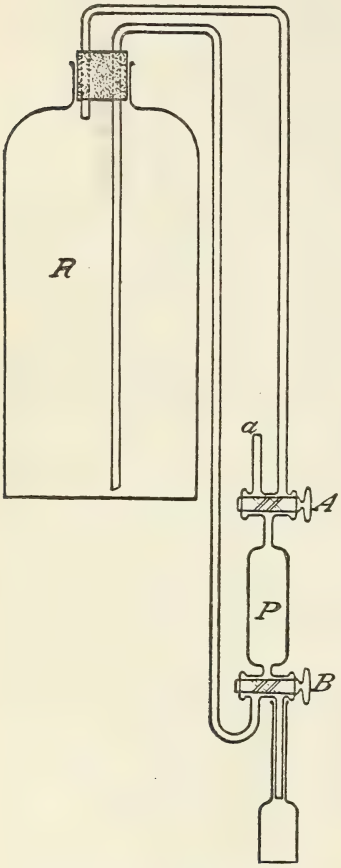

FIG. 7.—Acid bottle and pipette.

Special precautions must be taken to prevent dilution of this acid by the absorption of atmospheric moisture. The arrangement shown in figure 7 is most suitable for storing and delivering measured quantities of this reagent.

With the three-way stopcocks *A* and *B* in the position shown, acid is siphoned into the pipette *P*, the displaced air passing into *R*. To empty the pipette, *A* and *B* are turned to the position shown by the broken lines, air passing in at *a*. The acid adhering to the walls of the pipette dries this air so that when it passes into *R* on again filling the pipette there is no accumulation of moisture in the acid remaining in the reservoir. If such arrangement is not to be had, the acid should be kept in well-fitting glass-stoppered bottles of not more than one-half liter capacity.

5. BASIS OF PURCHASE.

(*a*) **Unit.**—Turpentine shall be purchased (*a*) by volume, the unit being a gallon of 231 cubic inches at 15.5° C. (60° F.), or (*b*) by weight. A gallon of turpentine at 15.5° C. (60° F.) weighs 7.19 to 7.30 pounds. The exact weight in pounds per gallon of any sample can be determined by multiplying the specific gravity at 15.5°/15.5° C. (60°/60° F.) by 8.33. *Example 1:* If the specific gravity at 15.5° C. is 0.8642, the weight per gallon at this temperature will be 0.8642×8.33=7.199 pounds.

When purchased by weight, quotations shall be by the pound or by the 100 pounds. The request for bids will state whether quotations shall be by the gallon, pound, or 100 pounds.

(*b*) **Correction of volume.**—The gallonage paid for shall be the volume corrected to a standard temperature of 15.5° C. (60° F.). The correction shall be deducted from (when the temperature of gaging is above 15.5° C.) or added to (when the temperature of gaging is below 15.5° C.) the gallonage as gaged. Such deduction or addition shall be computed on the basis of a coefficient of expansion for turpentine of 0.000945 per degree centigrade (or 0.000525 per degree Fahrenheit). *Example 2:* If the temperature at which the turpentine is gaged is 75° F. and the volume delivered (at that temperature) is 8,000 gallons, then 0.000525×15°×8,000 gallons equals the quantity in gallons which must be subtracted from 8,000 gallons to give the true gallonage at 60° F., or, if the temperature at which the turpentine is gaged is 10° C., then

0.000945×5.5°×8,000 gallons equals the quantity in gallons which must be added to the gaged volume of 8,000 gallons to give the true gallonage at 15.5° C.

(*c*) **Certification.**—Turpentine delivered in barrels, drums, or tank cars shall either be accompanied by an official gager's certificate showing the net contents of each container and also the temperature of contents at time of gaging, or shall be subject to gaging by the purchaser's inspector. In the absence of a statement of the temperature at the time of gaging on the official gager's certificate, or in case the barrels show evidence of loss by leakage or other shortage, the delivery shall be subject to reinspection and regaging by the purchaser's inspector.

TABLE 9.—*Correction to barometer readings.*[1]

(From circular F, Instrument Division, Weather Bureau, U. S. Department of Agriculture.)

Temperature.	Observed reading of barometer, in millimeters.														
	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780
°C.															
15.0	1.56	1.59	1.61	1.64	1.66	1.69	1.71	1.74	1.76	1.78	1.81	1.83	1.86	1.88	1.91
16.0	1.67	1.69	1.72	1.75	1.77	1.80	1.83	1.85	1.88	1.90	1.93	1.96	1.98	2.01	2.03
17.0	1.77	1.80	1.83	1.86	1.88	1.91	1.94	1.97	1.99	2.02	2.05	2.08	2.10	2.13	2.16
18.0	1.88	1.91	1.93	1.96	1.99	2.02	2.05	2.08	2.11	2.14	2.17	2.20	2.23	2.26	2.29
19.0	1.98	2.01	2.04	2.07	2.10	2.13	2.17	2.20	2.23	2.25	2.29	2.32	2.35	2.38	2.41
20.0	2.08	2.12	2.15	2.18	2.21	2.25	2.28	2.31	2.34	2.38	2.41	2.44	2.47	2.51	2.54
21.0	2.19	2.22	2.26	2.29	2.32	2.36	2.39	2.43	2.46	2.50	2.53	2.56	2.60	2.63	2.67
22.0	2.29	2.33	2.36	2.40	2.43	2.47	2.51	2.54	2.58	2.61	2.65	2.69	2.72	2.76	2.79
23.0	2.40	2.43	2.47	2.51	2.54	2.58	2.62	2.66	2.69	2.73	2.77	2.81	2.84	2.88	2.92
24.0	2.50	2.54	2.58	2.62	2.66	2.69	2.73	2.77	2.81	2.85	2.89	2.93	2.97	3.01	3.05
25.0	2.60	2.64	2.68	2.72	2.77	2.81	2.85	2.89	2.93	2.97	3.01	3.05	3.09	3.13	3.17
26.0	2.71	2.75	2.79	2.83	2.88	2.92	2.96	3.00	3.04	3.09	3.13	3.17	3.21	3.26	3.30
27.0	2.81	2.85	2.90	2.94	2.99	3.03	3.07	3.12	3.16	3.20	3.25	3.29	3.34	3.38	3.42
28.0	2.91	2.96	3.00	3.05	3.10	3.14	3.19	3.23	3.28	3.32	3.37	3.41	3.46	3.51	3.55
29.0	3.02	3.06	3.11	3.16	3.21	3.25	3.30	3.35	3.39	3.44	3.49	3.54	3.58	3.63	3.68
30.0	3.12	3.17	3.22	3.27	3.32	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	3.75	3.80
31.0	3.22	3.27	3.32	3.37	3.43	3.48	3.53	3.58	3.63	3.68	3.73	3.78	3.83	3.88	3.93
32.0	3.33	3.38	3.43	3.48	3.54	3.59	3.64	3.69	3.74	3.79	3.85	3.90	3.95	4.00	4.05
33.0	3.43	3.48	3.54	3.59	3.64	3.70	3.75	3.81	3.86	3.91	3.97	4.02	4.07	4.13	4.18

[1] These corrections apply to a mercurial barometer with brass scale. They can, however, be used for a mercurial barometer with glass scale, since the errors introduced thereby are negligible as applied to the work contemplated in this bulletin. For exact correction to be applied to such a barometer, see Smithsonian Physical Tables (1914), p. 119. An aneroid barometer should not be relied on.

For barometer readings below 640 mm. the correction can be interpolated, since the difference, at any particular temperature for each 10 mm. variation in barometer reading, is practically constant.

STATISTICS.

The Census Bureau, United States Department of Commerce, collects statistics on the production of turpentine and rosin every five years. Estimates of production are published annually, at the close of the naval stores season, March 31, in the Naval Stores Review of Savannah, Ga.

Both producers and consumers of turpentine and rosin have long desired that the Department of Agriculture collect periodical statistics covering production, stocks available for sale, and stocks in the hands of the chief consuming industries. These statistics are to serve as a guide to the producer in planning his next year's work, and to the consumer in purchasing, by giving to each accurate information concerning supplies on hand.

This information is expected to insure remunerative returns to the producer and to protect the user against exorbitant prices. The

producer will have some idea of the probable future demand and the consumer will know what the available supply is likely to be. Both will profit by the definite information made available at stated times. Six reports have so far been issued. The first showed production up to August 1, 1918, and the stocks in the hands of producers on that date, with the estimated total production for the 1918 season. The second showed total production for the season 1918–19, and the stocks in the hands of the producers on March 1, 1919. The third showed the stocks on the principal storage yards of the country, and the stocks in the hands of the chief consuming industries, March 31, 1919. The fourth showed the production in 1919 up to August 1, and also the stocks in the hands of producers and the chief consuming industries on August 1, 1919. In addition, this mid-season report included estimates of production for the entire season of 1919–20, based on the producers' estimates of production for the remainder of the season. The fifth showed the stocks on the storage yards of the country and in the hands of the principal dealers and jobbers on February 2, 1920. The sixth showed the total production of turpentine and rosin for the season of 1919–20, and the stocks in the hands of producers and consumers on February 2, 1920. The collection and publication of these semiannual reports on production and stocks of naval stores will be continued.

Table 10 shows the production of naval stores in the United States from 1910 to 1920, inclusive.

TABLE 10.—*Production of naval stores in the United States, 1910 to 1920.*[1]

(For naval stores years, April 1 to following March 31.)

Season.	Turpentine.	Rosin.
	50-gallon casks.	*Barrels of approximately 500 pounds each.*
1910–11.	595,000	1,970,000
1911–12.	638,000	2,125,000
1912–13.	680,000	2,267,000
1913–14.	640,000	2,132,000
1914–15.	512,000	1,706,000
1914–15.	[2] 540,000	[2] 1,620,000
1914–15.	[2 4] 553,000	[2 5] 1,649,000
1915–16.	470,000	1,565,000
1916–17.	535,000	1,782,000
1917–18.	473,000	1,577,000
1918–19.	[3] 340,000	[3] 1,114,000
1918–19.	[3 4] 372,000	[3 5] 1,237,000
1919–20.	[3] 362,000	[3] 1,217,000
1919–20.	[3 4] 392,000	[3 5] 1,375,000

[1] Estimates given in the Savannah Naval Stores Review for gum spirits and gum rosin, except as noted.
[2] U. S. Census figures.
[3] U. S. Department of Agriculture statistics.
[4] Includes wood turpentine.
[5] Includes wood rosin.

EXPORTS.

Exports of spirits of turpentine and rosin over the last 10 years are shown in Table 11. The figures for turpentine, given in terms of casks of 50 gallons, are based on the reports of the U. S. Department Commerce, in which the quantities exported are given in gallons. The figures for rosin exports are in terms of round barrels, weighing approximately 500 pounds gross. These have been calculated from the reports of the Department of Commerce, in which rosin exports are given in terms of the commercial or selling unit of 280 pounds gross.

TABLE 11.—*Exports of naval stores from the United States, 1910 to 1920.*

(For naval stores years, April 1 to following March 31.)

Season.	Spirits of turpentine.	Rosin.	Season.	Spirits of turpentine.	Rosin.
	50-gal. casks.	*500-pound round bbls.*		*50-gal. casks.*	*500-pound round bbls*
1910–11	286,942	1,263,496	1915–16	192,655	869,505
1911–12	377,475	1,421,935	1916–17	195,607	945,609
1912–13	432,680	1,417,205	1917–18	106,535	736,322
1913–14	377,774	1,470,970	1918–19	83,241	501,838
1914–15	236,253	820,138	1919–20	213,876	723,884

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